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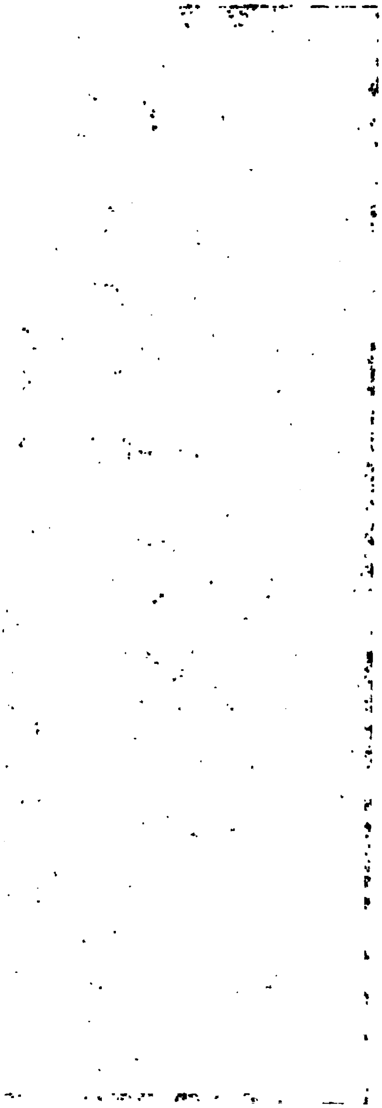
THE OLDEST WOMAN IN THE WORLD AND HER SON

Baba Vasilka is 126 years old, and her son Tudor is 101. They are peasants, and have lived all their lives in a little village in Bulgaria. They are typical examples of people who live to a great age by the use of soured milk, as it has been their principal food all their lives.



The Bacillus of Long Life

A Manual of the Preparation and Souring of Milk for Dietary Purposes, Together with an Historical Account of the Use of Fermented Milks, from the Earliest Times to the Present Day, and Their Wonderful Effect in the Prolonging of Human Existence

By

Loudon M. Douglas, F.R.S.E.

With 62 Illustrations

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PREFACE

THIS book has been designed with a view to meet an extensive demand for definite data on the subject of Soured Milks. The author has had this matter brought before him, times without number, by those inquiring for authentic information on the subject, and he has therefore considered it desirable to gather together such information as is available in connection with ancient and modern practice. He has endeavoured to present this to the reader in concise form.

The author is indebted to many friends for their assistance in getting the book together, and would specially mention Dr. H. B. Hutchinson, Bacteriologist, Rothamsted Experimental Station, for assistance in connection with the bacteriology of fermented milks; Mr. Thomas Douglas, of Wimbledon, who has assisted with the chemistry of the subject; Mr. S. Javrilovitch, of Belgrade, Servia, for local information and illustrations; Dr. Otokar Laxa, Bacteriologist, of Prague, Bohemia, for general assistance; the editor of *Bacteriother·py*, New York, U.S.A., for the use of the group of illustrations 30–44; the publishers of the *Centralblatt für Bakteriologie*, Jena, for the group of illustrations 14–29; and many others, some of whom are referred to in the text.

CONTENTS

ILLUSTRATIONS

The Bacillus of Long Life

THE BACILLUS OF LONG LIFE

CHAPTER I

INTRODUCTORY—HISTORICAL

THE milk industry is one of the oldest known to mankind, and it is difficult to imagine a time when milk in one way or another did not form a part of the diet of the human race. There is a good deal of evidence to show that in Paleolithic and Neolithic times, cattle were part of the possessions of the nomadic races; and, according to the Vedas, the manufacture of butter was known in India 1500 years B.C.

In the eastern part of Europe, milk has always been looked upon as one of the principal kinds of food, but not necessarily the milk of cows, as, from ancient times to the present day, the milk from

camels, buffaloes, sheep, and goats has been used indiscriminately throughout the East.

According to Layard,[1] "the Bedouins do not make cheese. The milk of their sheep and goats is shaken into butter or turned into curds; it is rarely or never drunk fresh, new milk being thought very unwholesome, as soon by experience I found it to be, in the desert. I have frequently had occasion to describe the process of making butter by shaking the milk in skins. This is also an employment confined to women, and one of a very laborious nature. The curds are formed by boiling the milk, and then putting some curds made on the previous day into it and allowing it to stand. When the sheep no longer give milk, some curds are dried, to be used as a leaven on a future occasion. This preparation, called *leben*, is thick and acid, but very agreeable and grateful to the taste in a hot climate. The sour milk, or *sheneena*, a universal beverage amongst the Arabs, is either buttermilk pure and diluted, or curds mixed with water.

"The camel's milk is drunk fresh. It is pleasant to the taste, rich, and exceedingly nourishing. It is given in large quantities to the horses. The Shammar and Aneyza Bedouins have no cows or oxen,

[1] *Discoveries in Nineveh and Babylon*, by Layard, chap. xiii.

The Pass of Bukova.—During the revolution of 1904, a number of Turkish soldiers, just before traversing this pass, were given coffee containing "café" by a Bulgarian coffee-seller, or keeper of a small khan. Whilst in the pass the poison began to take effect, and they realised that they had been poisoned. Fortunately for them, a peasant with three horses loaded with Yoghourt (soured milk) had taken advantage of their escort. The soldiers ate freely of the Yoghourt, which counteracted the effects of the poison.

those animals being looked upon as the peculiar property of tribes who have forgotten their independence, and degraded themselves by the cultivation of land. The sheep are milked at dawn, or even before daybreak, and again in the evening on their return from the pastures. The milk is immediately turned into leben, or boiled to be shaken into butter. Amongst the Bedouins and Jebours it is considered derogatory to the character of a man to milk a cow or sheep, but not to milk the camel. The Sheikhs occasionally obtain dates from the cities. They are eaten dry with bread and leben, or fried in butter, a very favourite dish of the Bedouin. . . ."

The practice is now the same as it was in scriptural times, when milk was looked upon as the principal article of diet, and throughout the Scriptures there are copious references to milk in different forms, some of which are of peculiar interest at the present day.

It may be noticed, for example, that milk is absent from the sacred offerings amongst the Hebrews, and this was ascribed by the late Professor Robertson Smith to the fact that all ferments were excluded from presentation at the altar,[1] it

[1] Ex. xviii. and xxiii.; Lev. ii. and xi.

being recognised that, owing to the hot climate, milk of all kinds became rapidly sour, and in this way came to be looked upon as only fit for consumption when in that condition. It has been suggested that the prohibition referred to is on the same level as the prohibition of the use of blood, "as milk has sometimes been regarded as a kind of equivalent for blood, and containing the sacred life."[1] To this day the wandering tribes of Arabia consider the milk of their camels and flocks more refreshing when it has been slightly fermented or soured by being poured into a milk-skin on the inside of which are still sticking sour clots from the previous milking, and there shaken for a brief period; but this slightly soured milk (the *Oxygala* of Pliny) is known widely in the East simply as leben (milk). The name is also applied to what we term buttermilk.[2]

The use of milk-skins for the carrying of milk is not confined to one country, as, while it is common all over the north of Africa, it is also known in the Pyrenees and in some parts of the Balkan Peninsula, the object being identical in each case; and when it is intended to make butter from the milk,

[1] *Encyclo. Biblica.*
[2] Burckhardt and Doughty.

Kabyles Souring Milk

In the north of Africa the use of soured milk is common, and the illustration shows Kabyles shaking a skin full of milk so as to sour it. The skin has previously been used for the same operation, and, as a consequence, clots of milk are left from the previous day's use, and thus fermentation is set up.

the skin is simply rocked between the knees until the butter separates, a process of butter-making which was also used after the introduction of earthenware churns.[1] Dried soured milk is also used by the Arabs, and it is reconstituted when required by rubbing it up with a little water, and it is known as *Meeresy*.[2] The ordinary soured milk is the common article of diet, and is looked upon as being necessary at every meal, and travellers frequently refer to the use of this product, as a few references will show.

Charles G. Addison states: "A supper was brought in on a round tray. In the centre was a huge pilaff of rice, and around it several small dishes of stewed meats, grilled bones, sour clotted milk called *yaoort*,[3] bits of meat roasted, etc. . . .

"We retired into a tent to breakfast, where we found an immense bowl of delicious fresh camels' milk, with thin hot cakes of unleavened bread, baked upon the ashes, ready prepared for us. The principal food of the Bedouins consists of flour and some camels' milk made into a paste, boiled, and eaten swimming in melted grease and

[1] *Annals of Dairying in Europe*, by Loudon M. Douglas.

[2] Burckhardt, *Bedouins*.

[3] This word is spelt in a great many ways by different writers: *Yoghourt* would seem to be the one most favoured.—Author.

butter; boiled wheat and beans dried in the sun and prepared with butter are a favourite dish. They are all remarkably fond of butter and grease; the butter is made in a goat-skin, suspended to the tent pole, and constantly shaken about by the women."[1]

Burckhardt[2] says: "The provisions of my companion consisted only of flour; besides flour, I carried some butter and dried leben (sour milk), which would dissolve in water. It forms not only a refreshing beverage, but is much to be recommended as a preservative of health when travelling in summer. These are our only provisions." With regard to the inhabitants of the Houran, Burckhardt relates that the most common dishes of these people are *bourgoul* and *keshk*. "In summer they supply the place of the latter by milk, leben, and fresh butter. Of the bourgoul I have spoken on other occasions; there are two kinds of keshk—*keshk-hammer* and *keshk-leben*. The first is prepared by putting leaven into the bourgoul and pouring water over it. It is then left until almost putrid, and afterwards spread out in the sun and dried, after which it is pounded, and, when called

[1] *Damascus and Palmyra*, by Chas. G. Addison, 1838.

[2] *Travels in Syria and the Holy Land*, by Burckhardt, 1822.

for, served up mixed with oil or butter. The keshk-leben is prepared by putting leben into the bourgoul instead of leaven; in other respects the process is the same. Keshk and bread are the common breakfasts. Towards sunset a plate of bourgoul, or some Arab dish, forms the dinner."

Again, Taylor[1] says: "I received a small jug of thick buttermilk, not remarkably clean, but very refreshing."

These references particularly refer to the East, from which it would appear that soured milk was universally known in ancient times as it is at the present day, and this remark applies not only to Egypt, Palestine, and Arabia, but throughout Turkey and the Balkan States, where the consumption of soured milk is equally common. It seems curious that the use of this commodity should have been confined for centuries to the East, as we shall see later on that its dietetic value is so great that it is really a wonderful thing that no one has taken the trouble to introduce its use to the Western nations until quite recently.

A curious example of how the virtues of such an article may be independently discovered by

[1] *Lands of the Saracens*, by B. Taylor.

another nation is to be found in Lapland, where reindeer's milk is the article used. "The reindeer's milk," says Acerbi,[1] "constitutes a principal part of the Laplander's food, and he has two methods of preparing it, according to the season. In summer he boils the milk with sorrel till it arrives to a consistence; in this manner he preserves it for use during that short season. In winter the following is his method of preparation: The milk, which he collects in autumn till the beginning of November, from the reindeer, is put into casks, or whatever vessels he has, in which it soon turns sour, and, as the cold weather comes on, freezes, and in this state it is kept. The milk collected after this time is mixed with cranberries and put into the paunch of the reindeer, well cleaned from filth; thus the milk soon congeals, and it is cut out in slices, together with the paunch, to effect which a hatchet is used, for no smaller instrument would perform the office of dividing that lump of ice. It is then separated into small pieces and eaten throughout the winter every day at noon, which is the Laplander's dinner-hour. It must be presumed, as it is served up without

[1] *Travels through Sweden, Finland, and Lapland and to the North Cape in the years 1798 and 1799*, by Joseph Acerbi, 1802.

THE HANDLING OF MILK IN THE PYRENEES

The handling of milk in the Pyrenees is, more especially in the villages, conducted in goat or sheep skins, in a similar way to the methods which prevail in Eastern Europe, and the picture shows a skin of milk on a small farm in the Pyrenees. The churning is very often performed by simply rocking the skin between the knees, acidity being induced by remnants of the previous day's milk ; souring of milk is induced by the same method.

being brought to the fire, that this is ice-cream in the greatest perfection: here are flesh and fruit blended with the richest butyraceous milk that can be drawn from any animal; but, notwithstanding the extraordinary fatness, which may be supposed to resist in a great degree the effect of cold, this preparation, as our good missionary remarks with a degree of feeling, as if his teeth still chattered whilst he delivered the account, chills and freezes the mouth in a violent manner whenever it is taken. The milk which is drawn late in the winter freezes immediately after being drawn. This is put into small vessels made of birchwood, and is considered by the Laplander as such an extraordinary delicacy, that he reserves it as the most acceptable present he can offer even a missionary. It is placed before the fire and eaten with a spoon as it is thawed. When put by, it is carefully covered up, because if the cold air gets to it afterwards, it turns of a yellow colour and becomes rancid."

Amongst the peasants at the present day, soured milk is known as *yoghourt*, a word which is spelt differently according to the locality in which it is used. The method of preparation is practically the same everywhere, and a short description of the

process as now carried out in one place would, with slight modifications, apply to the general method adopted all over the East.

"The culture," says a correspondent at Varna, "which is used for the preparation of yogourt, is known as 'Maya' or as 'Bulgarian Maya.' The milk which is to be converted into yogourt must first be freed from all bacteria by boiling and allowed to cool to the temperature of 45° C.; it is then inoculated with maya and maintained at an even temperature of 45° C. during several hours. There are two kinds of maya, or ferment, one known as sour, and the other as sweet maya.

"In Europe small stoves, made expressly for the purpose, are used to maintain the milk at the proper temperature. In this country, however, after the milk has been boiled, it is merely poured into a bowl and allowed to cool to approximately 45° C., then a tablespoonful of this tepid milk is well mixed (in a small bowl apart) with a similar quantity of maya, and the mixture, when it has become quite homogeneous, is added to the bowl of tepid milk and stirred slightly. (One tablespoonful of maya is sufficient to ferment one litre of milk.) A cover is then placed on the bowl and the whole is enveloped in flannel and left in

a warm place for three hours in summer, and somewhat longer in winter.

"The process of preparation is complete when the mixture assumes the appearance of a soft mass somewhat resembling cream cheese, but less solid. The flannel is then removed, the bowl uncovered and placed in a cool spot until needed for consumption. Of the yogourt thus prepared, a tablespoonful is kept to serve as maya for the following day.

"The best yogourt is prepared from sheep's milk, the second quality from buffaloes' milk, and the third quality from cows' milk. Yogourt forms an almost daily article of diet with the natives in this country." [1]

With regard to the time stated for the fermenting process, it must be noted that since the subject has been investigated so thoroughly, the time required for fermentation has been found to be nearer ten than three hours, but this will be dealt with in a subsequent chapter.

Historically it may be gleaned from the fragmentary references which we have given, that soured milk has, from time immemorial, formed

[1] Letter to the author, from Mr. H. Cavendish Venables, British Vice-Consul at Varna.

the principal article of diet of a great many peoples, and the notable feature in connection with it is, that in some countries where it is in daily use, the age limit for human beings seems to be very much extended, and it would appear that there is a direct connection between the use of soured milk and longevity. In Bulgaria, for example, it is stated that the majority of the natives live to an age considerably in excess of what is recognised as the term of life amongst Western nations, and inquiry has shown that in the eastern part of Southern Europe, amongst a population of about three millions, there were more than three thousand centenarians found performing duties which would not be assigned to a man of sixty-five years of age elsewhere. It is quite common to find amongst the peasants who live to such a large extent upon soured milk, individuals of 110 and 120 years of age.[1]

In the ancient dairy practice, as we have seen, soured milk was the principal product, and the extraordinary ages which are recorded of the patriarchs, if translated into the modern denomination, would not appear to be so imaginary after all,

[1] *One Hundred and Twenty Years of Life*, by Reinhardt; *The Secret of Longevity*, by an F.R.M.S.

when it is considered that we have thousands of examples at the present day of men and women enjoying quite as long a term of existence. It has been noticed also, that while these very old people are able to perform a certain amount of manual labour, there is not the same tendency to the mental decay which is so prominent and sad a feature amongst Western nations, at a period of about seventy or eighty years of age. It would seem, indeed, as if the habit of living long was well known in ancient times, and that, like many other of the valuable arts and sciences, it fell under a cloud during the Middle Ages, or, perhaps, the significance of the use of soured milk fell into neglect, and, even after the revival of letters in the sixteenth century, still remained obscure.

The discovery of micro-organisms in perishable products, which is attributable to Anthony Van Leeuwenhoek, a Dutchman, whose vocation was the polishing of lenses, and who lived between 1632 and 1723, altered our point of view, not only of disease, but of all the functions carried on by the lower organisms. Since Van Leeuwenhoek's time, the germ theory has grown to vast proportions and has more especially been applied with splendid results to the study of milk. As we shall

see later, the researches of modern investigators have led them to the conclusion that micro-organisms play such an important part in the milk supply, that it is impossible to carry it on safely without a knowledge of the bacteriology of the subject. This view began to prevail about 1890, some twenty years after Pasteur had shown what fermentation really meant. Since that time, the progress in dairying has been continuous, and, during recent years, attention has been directed to soured milk to such an extent that it has become necessary for all who are interested in the handling of milk and milk products to have a knowledge of the subject, as it seems clearly demonstrated that, under proper direction, there is every possibility of its forming an important element in the prolongation of life.

CHAPTER II

FERMENTED MILKS

THERE is considerable variety in the number of soured or fermented milks, and they are known by various names, such as Koumiss or Koomiss, which is prepared from mares' milk; Keffir, which was originally discovered in the mountains of the Caucasus, and which is prepared with Keffir grains; Leben, an Egyptian product prepared from the milk of the buffalo, cow, or goat; Matzoon, a soured milk which is prepared in Armenia from ordinary cows' milk; Dadhi, an Indian preparation from cows' milk. All of these owe their special characteristics to the fact of their having undergone lactic and alcoholic fermentation.

"Milk left to itself," says Blyth,[1] "at all temperatures above 90° F. begins to evolve carbon dioxide, and this is simply a sign and result of fermentation. If this fermentation is arrested

[1] *Foods, their Composition and Analysis*, by A. W. Blyth.

or prevented, the fluid remains perfectly sweet and good for an indefinite time. Besides the production of carbon dioxide during decomposition, a certain portion of milk sugar is converted into lactic acid, some of the casein and albumen are broken up into simpler constituents, and a small proportion of alcohol produced, which by oxidation appears as acetic acid, while the fat is in part separated into free fatty acids, which ultimately unite with the ammonia produced by the breaking up of the albuminoids. The main fermentation of milk is a special kind which of late years has been much studied, and is known as *lactic fermentation*. Accompanying lactic fermentation there is nearly always a weak butyric and a weak alcoholic fermentation."

One of the organisms causing *Butyric Acid Fermentation* is a bacillus 3 to 10μ in length, and about 1μ in breadth. It has power of movement, and when cultivated in gelatine, liquefies the gelatine, forming a scum on the surface. When the bacillus is sown into sterile milk, the following, according to Hueppe, are the changes:

"If the milk thus infected is incubated, on the second day a clear, slightly yellow fluid is seen under the layer of cream; this fluid increases from

day to day, so that gradually a column of fluid is formed which is quite clear above, but below is turbid; the casein, at first thrown down in a firm coagulum, in the course of eight days begins to be attacked, and by the end of two or three weeks most of it is dissolved. The filtered fluid gives the biuret reaction; it contains leucin, tyrosin, and ammonia; hence it is clear that the ferment acts to some extent as a digestive of albumen. In advanced butyric acid fermentation, the fluid is most offensive, and may have an alkaline reaction."

Lactic acid was first isolated by Scheele in 1780 from soured milk, but its exact constitution was not determined until later by Liebig, Mitscherlich, Gay-Lussac, and Pelouze: "It is widely distributed in nature, occurring in the sap of the vine and in most fermented liquids, especially in soured milk; it is not, however, present in fresh milk."[1]

In all the Eastern preparations referred to, the lactic fermentation is produced, followed by alcoholic fermentation, which is due to the slow decomposition of the milk sugar, the vinous fermentation being most readily set up in milks which contain a larger relative proportion of milk sugar and water, such as the milk derived from the mare, the sheep,

[1] *Dictionary of Applied Chemistry*, by T. E. Thorpe, C.B.

and the camel. As these fermented milks have different characteristics, it is necessary to the thorough understanding of the process of manufacture at the present day, to examine them in some detail.

Koumiss.—The greatest of all the fermented milks is koumiss, and it has been celebrated from the most ancient times until the present day, as being the principal food of the wandering tribes of Khirgiz, Bashkirs, Kalmucks, and Tartars, who inhabit the steppes of European Russia and the plains of South, Western, and Central Asia. According to Carrick, who has written an interesting volume on the subject,[1] the nomads who inhabit these vast territories are shut up under the most miserable circumstances during the winter time and at the advent of spring they roam over the steppes from morning to night, usually in the saddle. The milk yielded at such time by the mares is carefully collected, and these nomads consume enormous quantities of it in the fermented state, this habit having been in existence amongst them from time immemorial. It is said that the Scyth-

[1] *Koumiss or Fermented Mares' Milk and its Uses, and the Treatment and Cure of Pulmonary Consumption and Other Diseases*, by L. Carrick, M.D., 1881.

ians, long before the Christian era, used fermented mares' milk; and there are ornaments in existence in Russia, of Scythian origin, which exhibit in detail the preparation of koumiss from mares' milk. In historical times, the first mention of koumiss was in the twelfth century, when it is referred to in the Ipatof Chronicles. During the thirteenth century William de Rubruquis, a French missionary, wrote about his travels in Tartary, and he described how he had first become acquainted with koumiss, and how he found it savoury to the palate. Subsequent to this, however, there is very little mention of koumiss in Russian history, or, for that matter, in any other, and the first really scientific contribution on the subject was by Dr. John Grieve, who was a surgeon in the Russian army, and who in the year 1784 sent a description of koumiss to the Royal Society of Edinburgh,[1] of which he was a member, and the title of it was, "An Account of the Method of Making Wine called by the Tartars Koumiss, with Observations on its Use as a Medicine." Dr. Grieve strongly advocated the use of koumiss as beneficial in cases of wasting diseases, and subsequently it was adopted by the medical

[1] *Transactions of the Royal Society of Edinburgh*, vol. i.

profession, with the result that sanatoria for the treatment of pulmonary consumption were established at Samara and other places in Russia, and met with very great success; and at the present day such sanatoria are carried on, but the bacteriology of the subject now being thoroughly understood, the methods of preparation have been somewhat modified.

An interesting account of koumiss is given by Clarke,[1] who says:

"Everybody has heard of koumiss, and the brandy which the Kalmucks are said to distil from the milk of mares. The manner of preparing these liquids has been differently related, and perhaps is not always the same. They assured us that the brandy was merely distilled from buttermilk. The milk which they collect overnight is churned in the morning into butter; and the buttermilk is distilled over a fire made with the dung of their cattle, particularly the dromedary, which makes a steady and clear fire like peat. But other accounts have been given both of the koumiss and the brandy. It has been usual to confound them, and to consider the koumiss as their appellation for the brandy so obtained. By other information I

[1] Clarke's *Travels*, 1810.

could gain, not only here, but in many other camps which we afterwards visited, they are different modifications of the same thing although different liquors; the koumiss being a kind of sour milk, like that so much used by the Laplanders called *pina*, and which has undergone, in a certain degree, the vinous fermentation; and the brandy an ardent spirit obtained from koumiss by distillation. In making koumiss they sometimes employ the milk of cows, but never if mares' milk can be had, as the koumiss from the latter yields three times as much brandy as that made from cows' milk.

"The manner of preparing the koumiss is, by combining one sixth part of warm water with any given quantity of warm mares' milk. To these they add, as a leaven, a little old koumiss, and agitate the mass till fermentation ensues. To produce the vinous fermentation, artificial heat and more agitation is sometimes necessary. This affords what is called koumiss. The subsequent process of distillation afterwards obtains an ardent spirit from the koumiss. They call it *vina*. In their own language it bears the very remarkable appellation of *rack* and *racky*, doubtless nearly allied to the names of our East India spirit *rack* and

arrack. We brought away a quart bottle of it, and considered it very weak bad brandy, not unlike the common spirit distilled by the Swedes and other northern nations. Some of their women were busy making it in an adjoining tent. The simplicity of the operation and their machinery was very characteristic of the antiquity of this chemical process. Their still was constructed of mud, or very coarse clay; and for the neck of the retort they employed a cane. The receiver of the still was entirely covered by a coating of wet clay. The brandy had already passed over. The woman who had the management of the distillery, wishing to give us a taste of the spirit, thrust a stick, with a small tuft of camel's hair at its end, through the external covering of clay, and thus collecting a small quantity of the brandy, she drew out the stick, dropped a portion on the retort, and, waving the instrument above her head, scattered the remaining liquor in the air. I asked the meaning of this ceremony, and was answered that it is a religious custom to give always the first drop of the brandy which they draw from the receiver to their God. The stick having been plunged into the receiver again, she squeezed it into the palm of her dirty and greasy hand, and

after tasting the liquor, presented it to our lips."

Another interesting account of the preparation of koumiss is given by John M. Wilson in the *Rural Encyclopædia*,[1] and it shows that the methods in use about the middle of last century did not differ materially from those which existed centuries before.

Wilson says: "Khoumese is vinously fermented mares' milk. Any quantity of fresh mares' milk is put into wooden vessels; a sixth part of water just off the boil is mixed with it; an eighth part of old khoumese or of the sourest possible cows' milk is added; the mixture is kept from fifteen to twenty-four hours, covered up with several folds of coarse linen cloth and with a very thick board, and without being stirred or in any degree disturbed, in a moderately warm place till it becomes thoroughly sour, and sends up a thick mass to its surface; it is then beaten and pounded and stirred till the curd is not only broken, but so thoroughly mixed with the serum as to form a thick liquid; it next remains covered and at rest during twenty-four hours more, and it is finally put into a common butter churn and beaten and blended into a state of perfect homogeneity. It is now fit for use;

[1] 1845.

yet it acquires an increase of given properties if it be allowed to stand for a few days, and either then or now it would, if distilled, yield nearly one third of its own bulk of a weak spirit which will bear to be rectified. Whenever it is used it must be previously so agitated that its component parts may be well mixed together, and it may be kept either in pans for immediate use or in casks for more remote use; and if placed in a cool cellar it will remain good during three or four months."

Mares' milk owes its peculiar fitness for making koumiss to its containing a large proportion of sugar of milk, and readily undergoing the vinous fermentation, and it possesses a general medicinal reputation among the Tartars similar to that which asses' milk has partially acquired in Britain. "That mares' milk will undergo vinous fermentation and yield a certain quantity of spirit," says a writer in the *Magazine of Domestic Economy*, "is not generally known, and it was reserved for a nation of demi-savages to render this circumstance available as an agent of health, as well as an agreeable and nourishing beverage. Every educated person, however, has heard that the Tartars drink mares' milk, though few know that this milk is taken on account of its specific virtues alone, and

not as a substitute for cows' milk, of which they have abundance, and with which they adulterate mares' milk when scarce." But the koumiss is reputed to be much more medicinal than the mares' milk itself; and on account of its being free from all tendency to curdle in the stomach, and of its possessing most of the nutritive power of the milk in combination with native fermented spirit, it has been strongly recommended by some persons as a remedy for most or all cases of general debility, of nervous languor, and even pulmonary disease.

"Khoumese is called sometimes *koumiss* and sometimes milk wine."

From these references it will be seen that koumiss is an alcoholic drink made by the fermentation of mares' milk, but it is also frequently prepared from the milk of the camel and cows' milk. It is stated that a similar preparation to Russian koumiss is made in Switzerland from cows' milk simply by the addition of a little sugar and yeast to skim milk; "it contains more sugar and less lactic acid than Russian koumiss, and on account of the much greater proportion of casein contained in cows' milk, differs considerably from that prepared from mares' milk." Suter-Naef gives the composition

of a Swiss koumiss[1] manufactured at Davos as follows:

	In Grams. Per cent.	Per Litre (by weight).
Water	90.346	1019.64 grams.
Alcohol	3.210	36.23 "
Lactic acid . . .	0.190	2.14 "
Sugar	2.105	23.75 "
Albuminates . . .	1.860	20.99 "
Butter	1.780	20.09 "
Inorganic salts . . .	0.509	5.74 "
Free carbonic acid .	0.177	2.00 "

The ferments used in the preparation of koumiss are stated by Carrick to be of two different kinds, artificial and natural.

"Of the natural ferments two have been resorted to. One is mentioned by Grieve, which he borrowed from the Bashkirs of Orenbourg, and which simply consists in the addition of one sixth part of water and one eighth of the sourest cows' milk to fresh mares' milk; the other has been employed, and was, if I mistake not, first recommended by Bogoyavlensky. It is a very simple if rather a tedious method. New mares' milk, diluted with one third its bulk of water, is placed in the *saba*,[2] and while allowed to sour spontaneously, is con-

[1] *Dictionary of Applied Chemistry*, by Thorpe.

[2] A leathern bottle.

tinually beaten up. This milk gradually undergoes the vinous fermentation, and in twenty-four hours is converted into weak koumiss. The disadvantage of this mode of commencing fermentation is obvious—viz., the great waste of time in agitation. Hence it is only employed when no artificial ferment is obtainable.

"In starting the process of fermentation in mares' or any other kind of milk, therefore, an artificial ferment is more frequently employed than a natural one. The former is used only for converting the first portion of milk into koumiss; the latter is always resorted to afterwards.

"Of artificial ferments the variety is great, for besides all putrefying animal matters which contain nitrogen—such as blood, white of egg, glue, and flesh—certain mineral substances which act by souring the milk are also capable of exciting fermentation.

"Now, many of the nomads, whose mares either give no milk or are not milked in winter, commence the preparation of their koumiss in spring by borrowing a ferment from the animal, mineral, or vegetable kingdom. Thus a mixture of honey and flour is the favourite ferment with some races of nomads; a piece of fresh horse-skin or tendon is

preferred by others, while a few resort to old copper coins, covered with verdigris, for starting fermentation. In the choice of a ferment they are guided solely by habit and tradition. As it would be useless, almost impossible, to give a list of all the foreign substances that have been employed with the view of converting mares' milk into koumiss, it will be best to consider the simplest artificial ferments, and those most generally in use.

"The simplest way is that recommended by Bogoyavlensky, and adopted and modified by Tchembulatof.[1] It is prepared thus: 'Take a quarter of a pound of millet-flour, add water to it, and boil it down to the consistence of thick oatmeal porridge. Then heat separately, in another vessel, eleven pints of milk to boiling-point, and allow it to cool down. When its temperature has

[1] "I have brought forward Tchembulatof's receipt, which differs from Bogoyavlensky's in the use of a larger quantity of millet-flour, and in the boiling of the latter apart from the milk. Dr. Postnikof's plan is the following: Half a pound of millet-flour and a quarter of a pound of malt are mixed with a sufficient quantity of honey to form a paste, which is put into a clean jar, covered with a linen cloth, and placed on a warm stove. The mass soon begins to rise, and is then taken out, wrapped in a piece of muslin, and dropped into a clean earthenware vessel, containing about a quart of new mares' milk, which is placed in the same temperature that the paste was kept in. As soon as signs of fermentation begin to show themselves in the fluid, the paste must be removed, while the milk, after being stirred, should be left in the same temperature till bubbles appear (only in very small quantities) on its surface. The ferment is then ready."

fallen to 95° F., pour it into a wooden bowl or tub, and add the boiled flour to it. The upper and open part of the vessel is then covered with a piece of coarse linen, and left at rest—at a temperature of about 99° F.—from twenty-four to forty-eight hours. The appearance of small bubbles, which keep bursting on the surface of this liquid, combined with a vinous or acid odour, prove that the ferment is ready. To this fermenting fluid twenty-two quarts of new milk are gradually (*i.e.*, every ten minutes) added, and the whole mass is continuously beaten up for twelve hours. The temperature during stirring should never be higher than 94° F. The whole fluid soon begins to ferment, and after twelve hours a not unpleasant koumiss is ready. This should be filtered through a horse-hair or muslin sieve, after which it is fit for drinking. This liquid is called weak koumiss; but a limited portion of the lactine has undergone the lactuous and vinous fermentations, and thus the percentage of alcohol is small. Koumiss at an ordinary temperature remains weak for twelve hours after it has been beaten up, and then gradually passes into medium.'"

Curiously enough, the richness of cows' milk in fat militates against its being a good raw material

for the making of koumiss, owing to the production of small quantities of butyric acid, which follows upon the fermentation, so that it is desirable, if koumiss is to be prepared from cows' milk, that the fat should be first of all eliminated, so that the separated milk will then approximate to the composition of mares' milk.

"The chemical changes," says Hutchison,[1] "which take place in the milk under the double fermentation are not difficult to follow; the lactic ferment simply changes part of the sugar into lactic acid, the vinous ferment eats up a very small part of the proteid of the milk, and, at the same time, produces from the sugar a little alcohol and a good deal of carbon dioxide; the milk thus becomes sour, it effervesces and is weakly alcoholic, but the lactic acid causes the casein to be precipitated just as it does in the ordinary souring of milk, and the casein falls down in flocculi."

As will have been noticed, it is an essential part of the process of koumiss-making to keep the milk in a state of agitation during the period of fermentation, a process which is intended to permit of oxygen being taken up by the fermenting fluid, while, at the same time, the casein is broken up

[1] *Food and the Principles of Dietetics.*

into a state of fine division. The casein also, or at least a portion of it, becomes very soluble, and after twelve hours of fermentation the taste of the product is only slightly sour, and the milk taste still remains. This taste, however, disappears in twenty-four hours, owing to the rapid development of the lactic acid organisms. After this lapse of time the sugar is entirely destroyed, and the strong koumiss which results is a thin sour fluid which effervesces briskly, and in this condition will keep for an indefinite period. "The net change which has taken place in the original milk may be summed up by saying that the sugar of the milk has been replaced by lactic acid, alcohol, and carbon dioxide, the casein has been partly precipitated in a state of very fine division, and partly pre-digested and dissolved, while the fat and salts have been left much as they were."[1]

Violent stirring or agitation of the cultures does not seem to work so much by supplying oxygen to the fermenting liquid, as by ensuring a thorough distribution of the micro-organisms throughout the liquid, and thus dividing the casein.

The greater number of the organisms are facultative anærobes and oxygen is not necessary.

[1] *Food and the Principles of Dietetics*, by Robert Hutchison, M.D.

Again, koumiss put up in bottles on the first day is regularly shaken although air is excluded.

Keffir.—Keffir is a kind of fermented milk which has been in use in the Caucasus for quite a long time, as koumiss has been in the steppes. It differs from koumiss, however, in this respect, that it is prepared from either sheep's, goats', or cows' milk. The process is started by the addition of keffir grains to the milk, which is contained in leathern bottles. These keffir grains are small solid kernels which are kept in families and handed on from one generation to another.[1] The grains are the origin of the ferment, as they disseminate in the milk micro-organisms of a lactic yeast (*Saccharomyces kefir* Beyerinck and Freudenreich) and also the bacillus *Bacterium caucasicum*, which develop rapidly and split up the milk sugar into carbon dioxide, alcohol, and lactic acid. Small quantities of glycerine, acetic, succinic, and butyric acids are also formed, the casein and albumen being partly peptonised.[2] Keffir becomes slightly effervescent in twenty-four hours, and in that time develops a small quantity of alcohol, but after three days the amount of alcohol and lactic acid

[1] *Bacteria in Milk and its Products*, by Conn.

[2] *Dict. App. Chem.*, Thorpe.

is much increased.[1] It has been determined that the fermentation of the milk is due to *Saccharomyces kefir*, and that the *Lactobacillus Caucasicus* does not take any part in the fermentation, a fact which seems to be supported by the capacity of ordinary keffir for starting the fermentation in fresh milk in the same manner as the keffir grains. The use of this beverage seems to be universal throughout the Caucasus, and travellers in these regions have frequently referred to it. Thus Freshfield[2] states in one part of his book of travels as follows:

"The pig-faced peasant against whom we had at first sight conceived such an unjust prejudice turned out a capital fellow. He brought us not only fresh milk, but a peculiar species of liquor, something between public-house beer and sour cider, for which we expressed the greatest admiration, taking care at the same time privately to empty out the vessel containing it, on the first opportunity." And again:

"The hospitable shepherds regaled us, not only with the inevitable and universal airam or sour milk—if a man cannot reconcile himself to sour milk, he is not fit for the Caucasus—but with a

[1] *Nature*, July 23, 1884.
[2] *The Exploration of the Caucasus*, by Duncan W. Freshfield, 1896.

local delicacy that has lately been brought to the knowledge of Europe—kefir. This may best be described as 'effervescing milk.' It is obtained by putting into the liquid some yellow grains, parts of a mushroom which contains a bacillus known to science as *Dispora caucasia*. The action of the grains is to decompose the sugar in the milk, and to produce carbonic acid and alcohol. The grains multiply indefinitely in the milk; when dried they can be preserved and kept for future use; its results on the digestion are frequently unsatisfactory, as one of my companions learnt to his cost."

"It has been supposed," says Metchnikoff, "that the chief merit of kephir was that it was more easy to digest than milk, as some of its casein is dissolved in the process of fermentation. Kephir, in fact, was supposed to be partly digested milk. This view has not been confirmed. Professor Hayem thinks that the good effects of kephir are due to the presence of alcoholic acid, which replaces the acid of the stomach and has an antiseptic effect. The experiments of M. Rovigh, which I speak of in *The Nature of Man*, have confirmed the latter fact, which now may be taken as certain. The action of kephir in preventing

intestinal putrefaction depends on the lactic acid bacillus which it contains. Kephir, although in some cases certainly beneficial, cannot be recommended for the prolonged use necessary, if intestinal putrefaction is to be overcome. . . . Professor Hayem prohibits its use in the case of persons in whom food is retained for long in the stomach. When it is retained in the stomach, kephir goes on fermenting, and there are developed in the contents butyric and acetic acids, which aggravate the digestive disturbances. Kephir is produced by combined lactic and alcoholic fermentations . . . and it is the lactic and not the alcoholic fermentation on which the valuable properties of kephir depend; it is correct to replace it by sour milk, that contains either no alcohol or merely the smallest traces of it. The fact that so many races make sour milk and use it copiously is an excellent testimony of its usefulness."

There are two methods given by Flügge[1] for the preparation of keffir:

"In the first, the dry brown kefir grains of commerce are allowed to lie in water for five or six hours until they swell; they are then carefully

[1] Quoted by George M. Sternberg, M.D., LL.D., *Text-Book of Bacteriology*, 1898.

washed and placed in fresh milk, which should be changed once or twice a day until the grains become pure white in colour and when placed in fresh milk, quickly mount to the surface—twenty to thirty minutes. One litre of milk is then poured into a flask, and a full tablespoonful of the prepared *körner* added to it. This is allowed to stand open for five to eight hours; the flask is then closed and kept at 18° C. It should be shaken every two hours. At the end of twenty-four hours the milk is poured through a fine sieve into another flask, which must not be more than four fifths full. This is corked and allowed to stand, being shaken from time to time. At the end of twenty-four hours a drink is obtained which contains but little carbon-dioxide or alcohol. Usually it is not drunk until the second day, when, upon standing, two layers are formed, the lower milky, translucent; and the upper containing fine flakes of casein. When shaken it has a cream-like consistence. On the third day it again becomes thin and very acid. The second method is used when one has a good kefir and two or three days to start with. Three or four parts of fresh cows' milk are added to one part of this and poured into flasks which are allowed to stand for forty-eight hours with occasional

shaking. When the drink is ready for use, a portion (one fifth to one third) is left in the flask as ferment for a fresh quantity of milk. The temperature should be maintained at about 18° C., but at the commencement a higher temperature is desirable. The grains should be carefully cleaned from time to time and broken up to the size of peas. The clean grains may be dried upon blotting-paper, in the sun, or in the vicinity of a stove; when dried in the air they retain their power to germinate for a long time."

Leben.—In our earlier references to fermented milks in scriptural times, we observed that alcoholic fermented milks were not permitted to be presented at the altar. Such offerings, however, were quite allowable amongst the ancient Egyptians, the Arabs and Carthaginians,[1] and from remote antiquity these nations placed great value on this product. Leben, which is peculiarly associated with Egypt, is a soured milk prepared from the milk of buffaloes, cows, or goats. It is usually prepared by the boiling of the fresh milk over a slow fire, after which some fermented milk from a previous preparation is added to the warm article, and the fermentation takes place rapidly and is

[1] *Encyclo. Biblica.*

considered to be complete in about six hours.[1] The Egyptian leben is valued so highly that it is offered in hospitality to the passing stranger, and it is regarded as so much of a duty to present this milk, that in some parts of Arabia it would be looked upon as scandalous if any payment were received in return.[2]

Matzoon.—Matzoon is prepared in Armenia in somewhat the same manner as keffir is prepared in the Caucasus, and indeed it differs very slightly from keffir in composition. Its use is universal in Armenia.

Dadhi.—In India large quantities of fermented milk are used, under the name of Dadhi, and its characteristics are not unlike the similar products in Europe. The specific bacillus has been investigated by Chatterjee,[3] who concludes that it is somewhat akin to the *Bacillus bulgaricus* and the bacillus of leben (*B. lebenis*). Dr. Chatterjee gives a résumé of his investigations which sums up the whole matter thus:

"1. The fermented milk of India called Dadhi

[1] Conn.

[2] *Cyclo. of Biblical Lit.*, M'Clintock and Strong, and Burckhardt's *Arabia.*

[3] *The Indian Medical Gazette*, Sept., 1909, "A New Lactic Acid producing Streptothrix," by Gopal Ch. Chatterjee, M.B.

resembles in all essential points the Bulgarian fermented milk as well as the leben and other forms of fermented milk in use in the East.

"2. The causative element of the curdling process of Dadhi is a streptothrix having characters similar to the *Bacillus bulgaricus* and *Streptobacilli lebeni*, and *Bacillus caucasina* and the Long Bacilli of Mazun, in (1) not growing in ordinary media; (2) producing a large amount of lactic acid in milk; (3) producing, besides coagulation of casein and splitting up the sugar of milk into lactic acid, no other change in milk; (4) not producing any indol, nor peptone, nor saponification of fat, nor formation of any gas.

"3. It differs from the above by showing peculiar pink-stained granules, when stained with methylene blue and showing peculiarly convoluted chains in glucose agar.

"4. The importance of the organism lies in the fact that, as in the case of *Bacillus bulgaricus*, it kills all pathogenic non-sporing germs and also destroys all proteolytic gas-forming bacilli in milk."

In the account of these investigations the following table is given, showing the amount of lactic acid produced by different lactic acid bacilli in

one litre of milk, in terms of lactic acid—the culture being kept at 37° C.

Name of the Bacillus.	After 24 Hours.	After 48 Hours.	After 72 Hours.	After 96 Hours.	After a Week.	Remarks.
B. lactis ærogenes	1.8	...	10.08	...	...	Observed by Hall and Smith
B. coli communis	1.8	...	4.77	...	...	Observed by Hall and Smith
B. bulgaricus	12.8 -.4	16.5 -.4	20.2 -.4	... ...	22 -.4	Observed by Gabriel Bertrand and Weisweller; the initial acidity of the milk was 4
Matzoon Long stäbschen B.	10.8	12.	...	...	...	Observed by Düggeli
Streptobacillus lebenis	2.61[1]	...	...	...	...	Observed by Rist and Khoury
Streptothrix dadhi	10.8	1.08	11.25	11.70	18.5	Med. Coll., Calcutta

In different parts of the world sour milk is consumed in great quantities, and it is stated by Metchnikoff[2] that the chief food of the natives

[1] In their studies on Leben in the *Annales de l'Institut Pasteur* of 1899, Rist and Khoury, in speaking of the amount of lactic acid produced by *Streptobacillus lebenis* in milk, say "Nous avons mesuré cette acidité dans une culture sur petit lait de vingt-quatre heures; elle était .261 grms. per cent. exprimée en acide lactique," which will make the amount of lactic acid produced in one litre of milk 2.61 grms. The production of this small amount of lactic acid does not tally with the ordinary view of the vigorous lactic-acid-producing power of the bacillus.

[2] *Prolongation of Life.*

of tropical Africa consists of soured milk, and in Western Africa in the region south of Angola, the natives live almost entirely on this product, there being a difference in the curdled milks produced according to the nature of the microbial flora which is introduced.

It is stated[1] that in Servia, Bulgaria,[2] and Roumania there were 5000 centenarians living in 1896, and while many reasons are advanced for such an abnormal condition of affairs, it seems fairly certain that the sole reason why people in these districts live to such great ages is because of their mode of living and the fact that they live very largely on soured milk. The hygienic conditions throughout these countries are not such as would give the population in the towns and villages any special advantages in the prolongation of life, and while it may be stated that a pastoral and agricultural life are likely to contribute to longevity, these conditions would not account for a general tendency to live long in the countries referred to, more than in any other agricultural area. There are many countries throughout the world in which the pastoral and agricultural existence is general,

[1] *Prolongation of Life.*

[2] An accurate census of Bulgaria is being prepared and will exhibit the cases of long life in that country.

but it has not been shown that in these countries life is prolonged. Hence the conclusion has been forced upon investigators that the reason is to be found not in the pastoral conditions, but in the habit which has existed from time immemorial of consuming sour milk as a principal article of diet.

There is no curtailment of the use of fermented milks in Eastern Europe, and the methods of preparation at the present day are those which have been carried out from time immemorial. A local observer states that in Bulgaria yoghourt is made in nearly every household, especially in the spring and summer. The method of preparation is very simple: The milk is boiled until a quarter of its volume has evaporated, it is then cooled to 45° C. and the ferment added. This ferment is a portion of the yoghourt of good flavour and is called "Maya" or "Zakvaska." The vases, a kind of earthenware pot, are enveloped in woollen stuff or sheepskin and placed in a warm place near the chimney. In ten hours the yoghourt is made, and it is preserved in a cold place. The great reputation that the yoghourt has acquired in Western Europe has caused this "Maya" to become an article of commerce. It is sent out by rail hermetically sealed in tinplate boxes. According to

a Sophia chemist, the "Maya" is employed in the following manner: For a litre of milk it is necessary to take about 10 gr. of the ferment. This ferment is diluted with three times the amount of water and put into a bowl previously heated with hot water and dried. Into this bowl the milk, previously boiled and cooled to a temperature of 75° to 50° C., is poured; it is then covered over and put in a temperature of about 30° C., and, in default of a stove of constant temperature, the bowl is wrapped round with flannel or a plaid, and left to curdle for eight to ten hours. It is then ready for consumption. During winter, curdled milk keeps for several days, and in summer it becomes sour in from twelve to twenty-four hours.

A similar food to the yoghourt is prepared in the Balkan mountains from sheep's milk under the name of "Urgoutnik."[1] The milk is poured into a goatskin or sheepskin bag, and a little of the fermented milk added, and is then left for some hours in a warm place. The milk consumed is replaced by a fresh supply. In some of the Balkan countries, they are not content with the fermentation of the milk, they add a little alum, which, under the name

[1] See A. Rosam, *Österreichische Molkerei Zeitung*, 15, p. 31.

of "typsa," is well known for this purpose. The milk attains such a solid consistency that it can be put into a cloth and carried to market.[1]

The various forms of sour milk which have been described in the foregoing pages may be said to be of the traditional kind, and with the light of modern knowledge, it has been possible to determine exactly what constitutes the active principle in use in the milk consumed in these countries, and, as we shall see, this principle has been applied so that, at the present day, a pure fermented milk may be obtained in any country, and there is every reason to believe that should such be adopted as a general article of food, it would contribute to the prolongation of human existence.

It is due to Metchnikoff, of the Pasteur Institute, that so much prominence has been given to the use of fermented milks. He gave it as his opinion[2] that senility was caused partly by auto-intoxication or by the poison derived from putrefactive micro-organisms which inhabit the digestive track. These organisms increase with age, and under

[1] *Revue générale du Lait*, vii., pp. 8 and 9 (letter from Dr. Otakar Laxa of Prague, Bohemia, to the author).

[2] *On the Prolongation of Human Life*, by Élie Metchnikoff; also *The Century Magazine*, Nov., 1909, "The Utility of Lactic Microbes," by the same author.

certain unhealthy conditions multiply enormously, particularly in the large intestine. Having arrived at this knowledge, Metchnikoff set to work to devise some means of combating the influence of these harmful microbes, and set up the hypothesis that the tendency to longevity which is exhibited in Eastern countries is due to the consumption of lactic acid organisms in the shape of soured milk. These organisms are more powerful than those of a putrefactive character and inhibit their growth.

"In the presence of such facts," says Metchnikoff, "it becomes exceedingly important to find some means of combating the intestinal putrefaction which constitutes so incontestable a source of danger. Such putrefaction is not only capable of producing diseases of the digestive tube—*enteritis* and *colitis*—but even of becoming a source of intoxication of the organism in its most varied manifestations.

"It is some years since I proposed to combat intestinal putrefaction and its injurious consequences by means of lactic ferments. I thought the acidity produced by such microbes would be much more effective in preventing the germination of putrefying microbes than the small quantity of acids produced by *Bacillus coli*. On the other

hand, I had no illusion as to the difficulty sure to be encountered in any effort to introduce lactic microbes into the intestinal flora which has been preoccupied by a multitude of other microbes. To make surer of the result, I chose the lactic microbe, which is the strongest as an acid producer. It is found in the *yahourt* (yoghourt), which originates in Bulgaria. The same bacillus has also been isolated from the *leben* of Egypt; and it is now proved that it is found in the curdled milk of the whole Balkan peninsula, and even in the Don region of Russia."[1]

It is a short step from considerations like these to the adoption of the *Bacillus bulgaricus* as the most potent of the various lactic organisms which have been examined, and which is likely to play such an important rôle in the destiny of the human race. The *Bacillus bulgaricus* may claim to be the Bacillus of Long Life.

[1] *Century Magazine*, Nov., 1909.

CHAPTER III

THE CHEMISTRY OF MILK

The Composition of Milk.—Like all other organic substances, or those built up in connection with the life processes of plants and animals, milk is of complex composition. It is also very liable to change—every one is acquainted with its tendency to "go bad." This instability is more or less inherent in all highly organised chemical compounds, and, indeed, it seems to be necessary that the materials used in growth and nutrition should be very plastic in a chemical sense, in order, *e.g.*, that the constituents, say of a plant, may easily be transformed into the substances of the body of the animal which feeds on it.

The perishable nature of milk—the food of young and growing animals—is therefore essential, so that it may be changed easily into the blood, bone, muscle, etc., so abundantly required in the early stages of existence.

Milk is a complete food, and, therefore, naturally it is not a simple chemical compound, but a mechanical mixture of a number of substances. The present state of chemical knowledge on the subject does not permit of its composition being given in detail, but for practical purposes, such as those of measuring its purity and food value, this is not necessary.

A proximate analysis, in which, at least, some of the ingredients are lumped together, is sufficient, and has been adopted everywhere by analysts. On this basis the average composition of cows' milk may be stated as follows:

	Per cent.
Water	87.50
Fat	3.50
Casein and albumen	3.65
Milk sugar	4.60
Ash	0.75
	100.00

The constituents other than water added together form the "total solids," and they amount to 12.5 per cent.

	Per cent.
Water	87.5
Total solids	12.5
	100.0

THE CONSTITUENTS OF MILK

In the illustration, a pint of milk is shown in a glass jar, and the various percentages of water, casein, sugar, ash, albumen, and fat, which make up its constituent parts, are shown in separate bottles, the percentage of each being stated beneath.

Milk varies a good deal in composition; the different breeds of cows give varying qualities. The Shorthorn gives large quantities of milk of rather poor analysis, while the Jersey yields smaller proportions of very rich milk. During the period of lactation (the time which has elapsed since the cow gave birth to a calf), care in milking, food, health, etc., all have an effect on the quality of the milk.

The limits of variation may be stated as follows:

	Per cent.		Per cent.
Water	87.5	to	82.5
Fat	2.5	"	6.0
Casein and albumen	3.0	"	4.5
Milk sugar	3.5	"	6.0
Ash	0.6	"	0.8

These figures are extreme, and it is very seldom indeed that either the minimum or maximum is reached. Indeed, by the regulation laid down under Clause 4 of the British Sale of Food and Drugs Act of 1899, when the percentage of solids not fat falls below 8.5 per cent., and fat under 3 per cent., it is assumed that the milk has been adulterated. This regulation is a perfectly just one. While genuine milk may, in rare instances, show figures as

low as 7.1 per cent. of solids not fat, or 2.5 per cent. of fat, the right can hardly be claimed of supplying such an abnormal article to the public as milk of proper quality, and the dairyman who understands his business, and wishes to deal fairly with his customers, can, by attention to the conditions enumerated above which influence the composition of milk, entirely avoid the production of such a low-grade article.

In the nutrition of both plants and animals large quantities of water are needed. The solids must be supplied in solution or dissolved in the assimilative processes, and this cannot take place without water, which also conveys the dissolved solids to the various parts of the economy, and in the case of animals removes waste materials. For the most part, water passes through the body unchanged, but a certain proportion unites chemically with the food materials and assists in their digestion. It is therefore not surprising that seven eighths of milk is composed of water. Blood contains a similar proportion, and this agreement emphasises the fact that milk is a perfectly balanced food.

The fat of milk, which yields cream and butter, differs in some important respects from other

fats. Like these, it is made up chiefly of stearin, palmitin, and olein, but, in addition, it contains an abnormally large proportion of compounds of certain of the volatile fatty acids. It is these which give to butter its agreeable flavour. By the methods of Duclaux, the following is the approximate composition of butter fat:

	Per cent.
Stearin, palmitin, olein, and traces of myristin and butin	91.50
Butyrin	4.20
Capronin	2.50
Caprylin, caprinin, and traces of laurin . .	1.80
	100.00

Myristin occurs in nutmegs; butyrin in another combination flavours pineapples and rum; caprinin is found in cocoanut fat, mutton fat, and in the offensive odour given off by the goat (from which the name is derived); caprylin is a by-product of alcoholic fermentation, and also occurs in cocoa fat; laurin is found in sweet bay; from which it is evident that there are some curious relationships in flavouring materials.

Fats are very concentrated foods, furnishing a large amount of energy to the body. At one time they were classed together with starch, sugar, and

other carbohydrates as heat-producers, but the distinction which was drawn between the kinds of food which were thought solely to keep up the temperature of the organism, and those which produced force in work and other forms of bodily energy, has broken down, and by direct experiment has been found not to exist. It is usually calculated that one part of fat is equal in food value to about two and a quarter parts of any of the other carbohydrates. Milk fat or butter is more digestible than almost any other fat, and its importance therefore can readily be realised. All the above constituents of milk fat are composed of different proportions of carbon, hydrogen, and oxygen, but milk also contains minute quantities of lecithin, a fat containing phosphorus in addition. Lecithin is also found in the brain and nerve material of animals, in the yolk of egg, and in several plants.

The nitrogenous constituents of milk—casein and albumen—are usually estimated together, and they are reckoned as of equivalent food value. The name protein is very commonly applied to the total of these bodies in milk, or other animal and vegetable foods. They are composed of different proportions of carbon, hydrogen, oxygen,

and nitrogen, with small quantities of sulphur, while casein contains phosphorus in addition. Albumen exists to the extent of about 0.6 per cent. in milk. It is very similar in properties to egg albumen. The coagulum which forms on the surface of milk when boiled is largely composed of albumen. Casein is combined with, and kept in solution by, lime, soda, and calcium phosphate, and its amount averages a little over 3 per cent.

The remarkable property possessed by rennet, of curdling or coagulating casein, is well known; rennet is an extract from the stomach of the calf, and similar principles are present in the stomachs of man and other animals, so that the coagulation of milk is the first process in its digestion. If milk is gulped down in large quantities it is apt to coagulate in lumps, and digestion is much interfered with, but if it is taken hot and slowly, it coagulates in small pieces which are readily attacked by the gastric juice, and milk is then one of the most assimilable of foods.

Nature provides that the milk for young animals is supplied in finely divided streams, so that coagulation takes place in the best possible way.

The proteids are the most important constituents of food; they are abundant in the blood,

and build up the muscles, brain, nerves, and other bodily structures.

Besides these mentioned, milk contains traces of another proteid of similar composition called globulin.

The sugar of milk is not found anywhere else. It is a carbohydrate like cane and grape sugar—that is to say, the hydrogen and oxygen they contain are in the same relative proportions as in water. Milk sugar is not so soluble or so sweet as the other sugars. It does not ferment with ordinary yeast, but certain special yeasts which are made use of in the preparation of keffir, koumiss, etc., have the power of transforming it into alcohol. Its most remarkable property, however, is the facility with which, under the influence of certain bacteria, it is changed into lactic acid.

Every one is familiar with the souring of milk, but perhaps it is not so generally known that there are great differences in the results obtained in accordance with the conditions under which the souring takes place. The skilled butter-maker, by keeping the milk in a cool and cleanly dairy, obtains a sour milk of a characteristic and agreeable aroma and taste, which beneficially affect the flavour of the butter produced. On the other

hand, if milk is kept in hot and dirty surroundings, the development of acidity is accompanied by different bad tastes and odours, and it becomes unfit for use as a food. In the first case, the conditions are favourable to the maximum production of the lactic acid bacteria, and these occupy the field, and largely prevent the development of the other bacteria which are present—the survival of the fittest in the struggle for existence. In the second case, the impure surroundings swarm with the germs of many kinds of putrefactive bacteria, and the high temperature assists these to gain the upper hand. Again, the survival of the fittest, in the particular conditions. Even in cool and cleanly surroundings injurious taints may develop, especially if the milk has previously been subjected to a journey by road or rail, as is the case in the modern creamery system, where the farmers deliver their milk to a central creamery, where it is made into butter. In such establishments it is the regular practice to kill the germs, lactic and others, existing in the milk, by heating it to a high temperature. This process is called pasteurising, after the great French chemist and bacteriologist who invented it. Pure lactic cultures are added to the pasteurised milk, and the

souring process is under exact control, with the result that butter of uniform flavour and quality is produced. The same method is made use of in making the special sour milk described in this book, with, of course, modifications in the apparatus employed, to suit the smaller scale in which the manufacture is conducted.

The ash is the mineral matter which is left when milk, previously dried, is burnt in a crucible. It is a complex mixture, and, as we have seen, it amounts to about 0.7 per cent. of the milk. The process of burning destroys all the organic matter, and, at the same time, alters somewhat the state of combination of the inorganic or mineral elements. Attempts have been made from the analysis of the ash to reconstitute the composition of the mineral matter as it exists in the milk. The best known is that of Soldner, and the following is his calculation:

	Per cent.
Sodium chloride	10.62
Potassium chloride	9.16
Monopotassium phosphate	12.77
Dipotassium phosphates	9.22
Potassium citrate	5.47
Dimagnesium citrate	3.71
Magnesium citrate	4.05
Dicalcium phosphate	7.42

	Per cent.
Tricalcium phosphates	8.90
Calcium citrate	23.55
Calcium oxide, in combination with casein	5.13
	100.00

The presence of citrates will be noted in this analysis. Citric acid, which gives to lemons their acidity, and is also found in other fruits, has been proved to exist in milk to the extent of about 0.2 per cent. When alkaline or earthy citrates are burnt or oxidised in the blood, the citric acid is destroyed, and corresponding carbonates remain. No doubt the function of citrates in milk is to furnish to the body the earthy and alkaline carbonates which are required in certain of its parts.

The mineral constituents of milk have many important functions to perform in the building up and nutrition of the bodily organism. Phosphate of lime is the principal constituent of the skeleton, and the blood must be richly supplied with the alkalies, earths, and acids which are comprehended in the ash.

Milk contains traces of many other substances, the most important of which are several enzymes which assist in its digestion.

General Properties of Milk.—The appearance

of milk is known to every one; it ought to be a pure white opaque liquid, but very generally it is tinted a cream colour with anatto to give it an added appearance of richness. The average specific gravity is about 1.031; or, to put it another way, while a gallon of pure water weighs exactly 10 lbs., a gallon of milk weighs 10 lbs. 5 oz. It freezes at 31° F. and boils at about one third of a degree higher than water.

When milk is examined under the microscope, the fat is found to be distributed through it in a multitude of minute globules varying in size from $\frac{1}{16,000}$th to $\frac{1}{25,000}$th part of an inch, and occasionally they are much smaller and also much larger.

Fig. 1 is a micro-photograph showing the fat globules in whole milk. Fig. 2 is a micro-photograph of separated milk, and Fig. 3 a micro-photograph of cream, all under high magnification (450 diams.); from these figures the comparative number of fat globules present may be seen.

Fats distributed through a watery liquid in this finely divided condition form together what is called an emulsion, in which the particles of fat are kept apart by surface tension. The specific gravity of milk fat averages 0.93, and compared with water weighing 10 lbs., a gallon of fat would

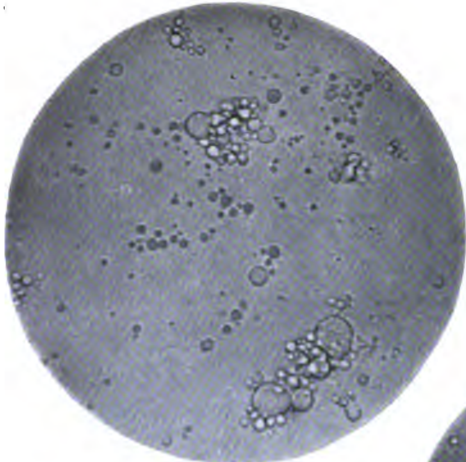


FIG. 1.—Micro-photograph of a Drop of Whole Milk, showing distribution of fat globules. (Magnified 450 diams.)

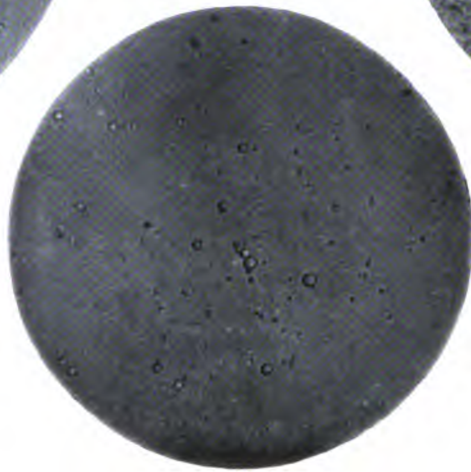


FIG. 2.—Micro-photograph of Separated Milk, showing the almost complete absence of fat globules as compared with whole milk. (Magnified 450 diams.)

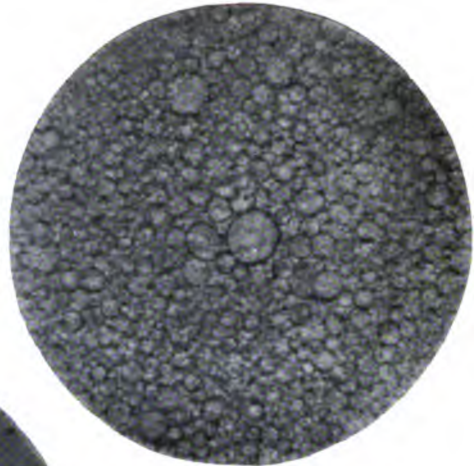


FIG. 3.—Micro-photograph of Cream, showing agglomeration of fat globules. (Magnified 450 diams.)

weigh 9 lbs. 5 oz. It is thus considerably lighter than the other constituents, and when milk is left at rest, the fat globules gradually rise to the top and float there, forming cream. The difference in specific gravity between cream and milk is taken advantage of in the mechanical separator, now so much used, and which makes such a thorough separation between the two. Cream is an article of the most varied composition, according to the ideas of the person who produces it, but it ought to contain at least 20 per cent. of butter fat, and may be made with a much larger percentage if necessary. When cream is agitated in a particular way, as by churning, the surface tension of the particles is overcome, and they run together into a mass which forms butter.

The casein of milk is not held in solution in the ordinary sense, but in a peculiar state of suspension called the colloidal condition, practically the whole of it remaining behind when milk is filtered through clay filters.

It is this state of suspension of the casein which makes milk opaque, but the opacity is considerably increased by the emulsified fat.

The coagulation of the casein in milk by the addition of rennet has already been referred to.

Acids, either mineral or organic, also precipitate it in the form of flakes. Skimmed milk is now largely used for the preparation of casein by this method, and the washed and dried precipitate is used very extensively in the arts for such varied purposes as the manufacture of billiard balls, paints, cements, etc.

The clear liquid which separates when milk is curdled with rennet is called whey, and contains the milk sugar and mineral salts. The sugar is manufactured from it on a limited scale, and is used as an ingredient in infant foods, and as a convenient medium in certain medical preparations. In Sweden a kind of cheese is made from whey, but the great bulk of it everywhere is used for feeding pigs.

The comparative composition of different varieties of milk is given in the following table:

	Human.	Cow.	Buffalo.	Goat.	Sheep.	Mare.	Ass.	Reindeer.	Whale.
Water	88.32	87.75	82.57	86.34	81.08	90.38	90.30	67.7	60.47
Fat	3.43	3.40	7.63	4.25	7.67	1.00	1.30	17.1	20.00
Protein	1.55	3.50	4.69	4.40	6.08	1.98	1.80	10.9	12.42
Milk Sugar	6.44	4.60	4.30	4.26	4.26	6.28	6.20	2.8	5.63
Salts	0.26	0.75	0.81	0.75	0.91	0.36	0.40	1.5	1.48
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.0	100.00
Specific Gravity	1.032	1.0315	1.033	1.033	1.038	1.034	1.033	....	....

FIG. 4 is a photograph of two Petri dishes, which have been inoculated with ordinary milk (A), and milk that has been subjected to sterilisation (B). The whitish bacterial colonies on A are due to enormous numbers of organisms, while B is quite free from such growth.

For the production of a reliable lactic food, it is essential that certain precautions as to the treatment of the milk, and the maintenance of a suitable temperature during the growth of the lactic bacteria, should be observed.

In the first place, milk immediately after extraction from the cow contains only a few organisms, but these multiply so rapidly that in a few hours the bacterial content may amount to many millions per ounce. In preparing a pure culture of any specific organism, then, care must be taken to destroy all the bacteria that have accidentally found their way into the milk, inoculating with the organisms it is desired to cultivate. This is best accomplished by heating the milk to the boiling-point of water for about thirty minutes, by which time almost all the undesirable bacteria have been killed.

The milk of the cow differs a good deal from human milk, and where the former is used for the feeding of children it is usual to add milk sugar to it, and otherwise alter it to bring its composition more in harmony with the human article. The high concentration of the milk of the reindeer and the whale is noteworthy. Perhaps this may be due to the low temperature conditions in which these animals live, necessitating strong nutriment to enable their young to make proper progress in growth and development. On the other hand, the milk of the ass is poor in quality, and probably on this account it is more readily assimilated by those of weak digestion, to whom it is sometimes recommended. Goats' milk is richer than either cow or human milk, and its nourishing properties are well known. The goat is usually free from tuberculosis and other diseases which affect the cow, and its milk is therefore a very safe article to use.

The Analysis of Milk.—While the analysis of milk can only be made by a competent chemist, there are a number of simple tests and observations by which any intelligent person can obtain a fair idea of its quality. The taste and smell afford some guide, as also the general appearance.

To judge of the latter, place some of the milk in a tumbler or other clear glass vessel. If the milk is of good quality it will be quite homogeneous and opaque. Any flocculent matter indicates either disease in the cow or that the milk is old and bacteria have multiplied in it and altered its composition. When the milk has stood long enough for the cream to rise freely, the latter should form a perfectly homogeneous and strongly defined layer on the top. The quantity of cream may be measured in a creamometer, which consists of a small glass cylinder graduated at the top (Fig. 5). It is filled with milk to the top graduation line, and when the cream has risen, the percentage quantity of the latter which has separated can be taken off.

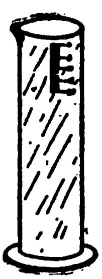


Fig. 5. The Creamometer

The colour should be like that of porcelain, but, as already stated, it is a common thing for the dairyman to add a small quantity of anatto or an aniline dye of a similar shade, to give the milk a rich creamy tint. If the milk is of a reddish colour this may be caused by blood from the udder, although certain foods, such as beets, mangels, and carrots sometimes give a similar tint. The milk given by cows immediately after calving is

TESTING-GLASS FOR EXTRANEOUS MATTER IN MILK.

FIG. 6.—A piece of muslin is folded as shown and a measured quantity of milk is passed through the funnel; from the sediment left in the muslin, the percentage of extraneous matter may be arrived at.

called "colostrum" or "biestings," and is of a yellow or yellow-brown colour. It is much thicker than ordinary milk, and coagulates in boiling.

In dirty byres in which care is not taken in milking, quite considerable quantities of hairs, pieces of manure, and other filth may get into the milk. Usually the milk is strained by the dairyman, but sometimes this is omitted or carelessly done. To test for dirt, a ribbed glass funnel is useful. Get a piece of the finest muslin about twice the diameter of the funnel, fold over twice, so that it becomes one quarter of its original size; open one of the sections and place in the funnel; pass the milk into this. It will run through quickly and some water may be run into the funnel to clear away the last traces of milk. The filter cloth can then be opened out and any dirt retained will become visible. The apparatus is shown in Fig. 6.

If a glass funnel is not available, a very small jelly bag can be made of fine gauze and used in the same way. The washing water should be used in small quantities and directed to concentrating the dirt in the apex of the bag. After washing, the latter can be turned outside in, to permit of readier examination of the dirt. The

bag should be well washed in cold water, then boiled and dried, and is then ready for future use.

The acidity of milk is a very useful guide to its age. Milk has the curious property of being "amphoteric," *i.e.*, it is both slightly acid and slightly alkaline when fresh. As its age increases, however, so does its acidity, and at a rate varying with the temperature and moisture contents of the atmosphere in which it is placed. Old and acid milk is heavily contaminated with bacteria, a proportion of which are likely to be injurious to health.

The simplest method of testing the acidity is to procure a few little books of blue and red litmus test papers, and these can be had from any philosophical instrument maker or laboratory furnisher. The strips of test paper are torn out and dipped in the milk. When the milk is quite fresh it will, owing to its amphoteric condition, change the red litmus paper slightly blue, and the blue litmus paper slightly red. Old milk changes blue litmus paper to a bright red because of its decided acidity.

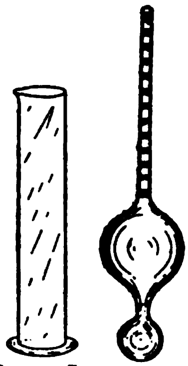


FIG. 7. Lactometer and Test Tube

The above tests do not indicate if the milk is poor or rich, but this can be determined by the lactometer, an instrument for ascertaining in a simple way the specific gravity. The lactometer is shown in Fig. 7.

It is graduated usually from 25° to 36°, corresponding to specific gravities 1.029 to 1.038. It is graduated to degrees and half degrees. Sometimes a thermometer is combined with the instrument. The specific gravity rises as the temperature is lowered and decreases with increase of temperature, so that it is important to make the test at the figure at which the lactometer was graduated, which is usually 60° F. Failing this, an allowance has to be made for higher or lower temperatures. The milk to be tested is well mixed, and placed in a deep vessel, and the lactometer placed in it, holding it at first at an angle. It stands upright and remains deeper or higher according to the specific gravity. The reading is taken on the stem at the level of the milk. As the latter is drawn up a little round the stem, about a half degree should be added on to get the true figure. Thus, if the apparent reading is 31, the true reading may be taken as 31.5. This is the average figure for good milk, corresponding to a specific gravity of 1.0315;

anything above this is all to the good. Lower readings mean inferior quality, the latter being proportionate to the lowness of the readings. The tests are most conveniently made in a glass cylinder (Fig. 7), which may be purchased with the lactometer. As there are many inaccurate instruments in the market, it is necessary to go to a reputable maker, because an unreliable lactometer is worse than useless.

The following table gives, in a condensed form, the allowances to be made when the temperature is above or below the standard (60° F.):

Temperature.	Reading of Lactometer.											
Degs. F.												
40 . . .	23.5	24.5	25.5	26.4	27.3	28.2	29.1	30.0	31.0	31.9	32.8	33.7
45 . . .	23.8	24.8	25.9	26.8	27.8	28.6	29.5	30.4	31.3	32.3	33.2	34.2
50 . . .	24.1	25.1	26.1	27.0	28.0	29.0	29.9	30.9	31.8	32.8	33.7	34.7
55 . . .	24.5	25.5	26.5	27.5	28.5	29.5	30.4	31.4	32.4	33.4	34.3	35.3
60 . . .	25.0	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0
65 . . .	25.5	26.6	27.6	28.7	29.6	30.7	31.7	32.8	33.8	34.8	35.8	...
70 . . .	26.1	27.2	28.2	29.3	30.2	31.3	32.4	33.4	34.5	35.5	36.5	...
75 . . .	26.8	27.8	28.8	29.9	30.8	32.1	33.1	34.2	35.2	36.3	...	...
80 . . .	27.4	28.4	29.5	30.7	31.6	32.8	33.9	35.9	36.1	...	...	...

Thus if the thermometer indicates 40° F., and the lactometer 29.1°, the true reading at the standard temperature of 60° F. is 31°, corresponding to a specific gravity of 1.031. Intermediate figures

can readily be averaged. Care should be taken to wash the lactometer with cold water under the tap, as otherwise the milk will dry on it and render it inaccurate.

CHAPTER IV

HANDLING OF MILK

MODERN DAIRY PRACTICE

As we have seen, the dairy industry is a very ancient one, and has been intimately associated with the development of civilisation.

Within historical times dairying has always formed a prominent feature in connection with agriculture, and the use of milk in one form or another has been common to every civilised nation.[1]

The greatest progress, however, in the study of milk has taken place since about the year 1890, at which time the dairy industry seems to have attracted the general attention of food specialists and scientific investigators throughout the world. Since then it has been considered worth while to enact laws in different countries with regard to the regulation and control of the milk supply.

Since 1903 there has been an International

[1] See *Annals of Dairying in Europe*, by Loudon M. Douglas.

Dairy Federation formed, and it has held conferences at Brussels, Paris, The Hague, and Buda-Pest, and in 1911 it will hold a conference in Stockholm. The Federation was started in a very humble way in Brussels, and owes its origin, to a large extent, to a distinguished Belgian agriculturist, Baron Peers of Oostcamp, Bruges; but at the present day a general committee composed of representatives of nearly every civilised nation has been formed, and delegates from such countries attend the Congresses, which are held every two years. The literature which has arisen out of these International Congresses has been disseminated in different countries, and has been instrumental in placing the dairy industry on a thoroughly scientific basis.

Milk Supply of the United Kingdom.—The milk supply of the United Kingdom has steadily grown from year to year, and in relation to the population works out at fifteen gallons per head. The manner in which these figures are arrived at is shown in the following estimate:

The population of the United Kingdom is now about 45,500,000. The number of cows or heifers in calf or in milk in June, 1909, was 3,360,600; the number in 1910 was probably about 4,400,000.

Of these about 300,000 were heifers that had not yet produced any milk. The actual milking class, therefore, comprised about 4,100,000 cows and heifers; of these, about 600,000 were heifers that calved in the winter and spring of 1909–10, and 300,000 were heifers that calved in the summer and autumn of 1910. The number of cows that produced two or more calves may be taken to be about 3,200,000; of these about 600,000 should have produced their second calf in the winter and spring 1909–10, and would be milked as heifers in the summer and autumn of 1910; the number of mature cows from which a full season's supply of milk was obtained during the twelve months from June 5, 1909, to June 4, 1910, was apparently about 2,600,000. A large quantity of milk is yielded during the year by cows sold or lost during the twelve months before the census. Possibly ten per cent. of the milk produced in the twelve months from June, 1909, to June, 1910, was yielded by cows that were sold or lost before the census of June, 1910.

It is estimated that the 3,200,000 cows (including the 600,000 that up to the winter of 1909–10 were heifers) produced, on the average, 44 cwts. (480 gallons) of milk per head in the twelve months from June 5, 1909, to June 4, 1910; the 300,000 heifers that calved in the summer and autumn, 30 cwts. (330 gallons) per head; the 600,000 heifers that calved in the winter and spring of 1909–10, 15 cwts. (165 gallons), making the total quantity of milk produced in the twelve months by cows and heifers on the farms, and that produced calves during the twelve months (June, 1909–1910), 158,800,000 cwts. (1,746,800,000 gallons), or about 426 gallons per head, and about 400 gallons per head for all the cows and heifers in milk or in calf in 1910. There remains to add the milk yielded by the cows that were sold during the twelve months, and of cows

and heifers in feeding pastures that were milked during the twelve months, June to June, 1909–10, and which probably formed one tenth of the whole supply, making the total supply for the twelve months 176,444,000 cwts., or 1,940,884,000 gallons. This equals 2 tons, or 440 gallons per head, crediting the whole supply to the 4,400,000 cows and heifers in milk or in calf in June, 1910. At 7¼d. per gallon the value of milk produced in the United Kingdom in the twelve months was £58,600,000. Including the value at birth of the calves, the total value of the produce of the milk-giving class would be about £62,000,000. The value of the milk, butter, cheese, and cream sold or consumed in farmhouses would be about £48,000,000, or equal to about 24 per cent. of the gross annual income of farmers.

The average consumption of new milk is about 15 gallons per head of the population. During the twelve months of 1911, the quantity required for this purpose will be about 682,500,000 gallons, or about 35 per cent. of the total supply; calves will require about 10 per cent. of the supply; the quantity available for butter and cheese will equal about 55 per cent. of the supply.[1]

The Milk Industry in the United States.—In the United States of America, where the habits of the people are somewhat analogous to those in the United Kingdom, it is estimated that the milk from five million cows is annually consumed, which averages twenty-five and one half gallons

[1] Adapted from a report by Robert E. Turnbull, in *Live Stock Journal.*

per year for each person, or equal to an ordinary sized tumblerful each day.[1]

Such a vast industry, so intimately associated with the food of the bulk of the people, naturally invites the closest study, and, as a consequence, the literature on the subject, which has arisen during the last twenty years, has been of a voluminous character, not only from the point of view of practice, but from that of bacteriology, chemistry, and hygiene.

A pure milk supply is essential to health, and it seems unfortunate that the ordinary milk producer should, in a great many cases, take up an antagonistic attitude to the scientific methods of handling milk. There is a body of opinion being created, however, which is likely to alter this attitude in the next generation, and this is attributable to the fact that so much excellent work has been done at numerous dairy colleges and institutes in all civilised countries that the dairy industry is emerging from a period of rule-of-thumb procedure to its proper place as one of the technical arts.

Transmission of Disease in Milk.—It is not to be wondered at that the handling of milk should

[1] *Facts about Milk*, by R. A. Pearson, B.S., Washington.

now be regarded as a technical business, seeing that milk-borne disease is one of the commonest with which we have to deal.

The commoner diseases which have been transmitted by milk are scarlet fever, typhoid, diphtheria, tuberculosis, sore throat epidemics. Others of a more complex character have been traced to the same source of infection, and the clearest possible evidence has been furnished of the transmission of diseases by means of micro-organisms, which have contaminated the milk supply.

It is therefore necessary to watch over the milk from the source of supply to its consumption. It is primarily on the farm and in the cow-house that methods of handling in a hygienic way should be insisted on, as microbial contamination increases at a prodigious rate, and it is the early microbe therefore which does the most damage.

The milk in the udder, for all practical purposes, may be assumed to be sterile, and the contamination which takes place originates, therefore, from external sources.

One of the principal means of infection is from hairs which fall from the cow into the milk, and many of which are carriers of dangerous micro-organisms.

There is also a certain amount of offensive dirty matter which may fall into the milk-pail, and carry with it undesirable germs.

These impurities may, to a certain extent, be eliminated by good straining, but a surer prevention is to have the cow-house perfectly clean and free from dust, as dust specks are in many cases the vehicles of disease germs. Cleanliness is, in fact, the essential feature in modern dairying, not only in the cow-house, but in the milking utensils, the drainage, etc., and, above all, the milker should be of cleanly habits.

The flavours of milk sometimes arise from the absorption of evil-smelling gases in the cow-house, or from a peculiar taint from certain roots and feeding stuffs, and in such a case it is desirable that aëration should take place in a fresh clear atmosphere, so that oxygenation may have the effect of eliminating and destroying the foreign odours and flavours which may be present. If this process of aëration is carried out at blood heat, the result is generally highly satisfactory.

Milk Management.—There have been many excellent tables of rules published for the management of dairies in different countries, but they are necessarily framed within certain limitations which

apply to all. The following is an excellent set, which put concisely the conditions necessary to be observed in the modern cow-house:

1. The cow should be sound—no disease should exist in the animal.
2. The feed should be good and free from aromatic substances. If these aromatic foods are used, they should be employed according to those methods which will not cause odours or flavours to appear in the milk.
3. The cow should be groomed, and hair about the udder preferably clipped.
4. The udder should be moistened during milking.
5. The milker should be a neat, tidy person.
6. The milker should be free from disease, and should not come in contact with any communicable disease.
7. The milker's clothes and hands should be clean while milking.
8. The pail should be sterilised.
9. The stall should be such as to reduce the amount of disturbance of dust and dirt.
10. There should be good light, good ventilation, and good drainage in the cow-house.
11. The cow-house should always be kept clean.
12. Feeding and bedding, unless moist, should be done after milking.
13. A dustless milking-room is desirable.
14. Milk should not stand in the cow-house.
15. If milk is aërated, it should be done before cooling and in pure air.
16. The sooner the milk is cooled after milking the better.
17. Keep the milk as cold as possible when once cooled.[1]

The supply of milk is conducted, to a large extent, by towns' dairies, which depend for their supplies upon the dairy farm in the country, and

[1] *Care and Handling of Milk*, Marshall and Wright, Bulletin 221, Michigan, 1904.

it is obvious that a certain period of time must elapse, in the generality of cases, before a town's dairy receives its supply in the ordinary course, and this constitutes the greatest difficulty in modern dairy practice, owing to the liability of the milk to absorb bacteria, which during transit may multiply enormously.

The multiplying of bacteria in milk at different temperatures is easily demonstrated, and the result of this has been stated in various forms many times over. As a graphic means, however, of showing the increase that takes place in the numbers of germs present, and the consequent product of acidity, the table below by Conn may be given.

The consequent result of the increase in bacteria is the production of lactic acid, which produces the souring so familiar in milk which has been kept in the household at a high temperature.

Numbers of Bacteria per c.cm. in Milk kept at Different Temperatures.

Number at Outset.	In 12 hrs. at 50° F.	In 12 hrs. at 70° F.	In 50 hrs. at 50° F.	In 50 hrs. or at time of curdling at 70° F.	No. hrs. to curdle at 50° F.	No. hrs. to curdle at 70° F.
46,000	39,000	249,500	1,500,000	542,000,000	190	56
47,000	44,800	360,000	127,500	792,000,000.36 hrs.	289	36
50,000	35,000	800,000	160,000	2,560,000,000.42 hrs.	172	42

What actually happens is that the lactic acid is produced by the breaking up of the milk sugar, and the appearance of this sourness is an indication that a period has been reached in the age of the milk which may be described as being—unwholesome.[1]

It is necessary, therefore, for the town's milk dairy to be equipped in such a way as to deal promptly with the milk supply.

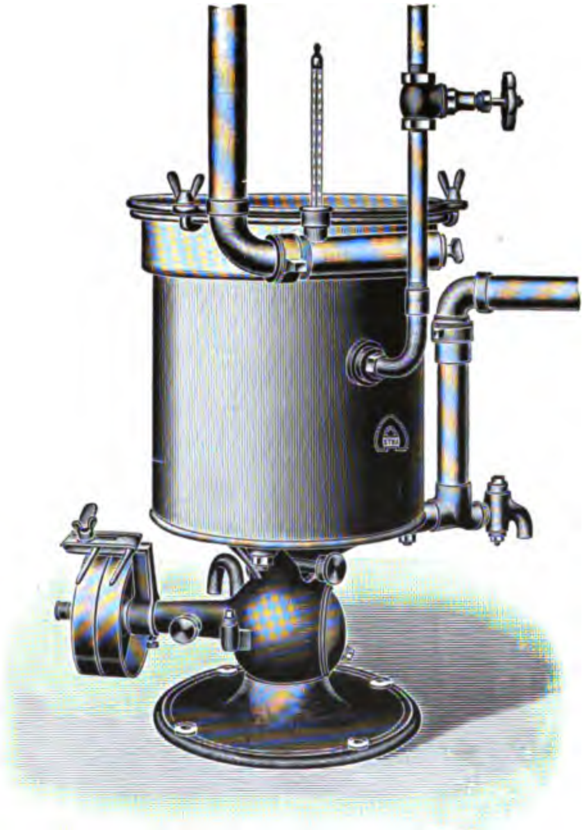
We have seen that the milk should first of all be aërated at blood heat, so as to liberate objectionable odours, after which it should be cooled to as low a temperature as possible, by means of well water. When these operations have been performed on the farm, milk should be sent as rapidly as possible to the distributing towns' dairies, and should be transported in refrigerated waggons, cooled preferably with ice, during the journey. On arrival at the town dairy, it will be necessary to pasteurise the milk—that is to say, the milk should be heated to such a temperature as will destroy any pathogenic organisms which may be present, and the pasteurising temperature should therefore be in excess of the thermal death-point of all such organisms.

[1] *Journal of the Royal Society of Arts*, March 6, 1908—"Modern Dairy Practice," by Loudon M. Douglas.

Pasteurisation owes its origin to Pasteur, and has become an adopted method throughout the dairy industry, and there are many mechanical devices termed "pasteurisers" (see Fig. 8) which are used for the carrying out of this particular operation. The form of one of these is that of a vertical jacketed cylinder with paraboloidal surface, around which steam is made to pass, so as to maintain the temperature at about 176° F. Milk is allowed to flow in at the bottom of the paraboloidal surface, and is caught by mechanical agitating arms, which revolve at a given speed, and by this action milk is distributed centrifugally over the paraboloidal surface, and is forced out by the same action, at the top of the apparatus, after being heated.

The centrifugal action is sufficient to raise the milk some three to four feet, through a tube, and this is taken advantage of so as to cause the milk to flow over a conical cooler, described as a primary cooler, and in which water is made to circulate. As the hot milk descends over the conical cooler it gives up most of its acquired heat to the water, and, in practice, is reduced in temperature to within 4° of the temperature of the water.

Below this primary cooler is fixed a cooler of



PASTEURISER

FIG. 8.—The milk enters from the bottom and circulates to the top of the inside cylinder, which is paraboloidal in construction. It is heated as it passes through the apparatus, and is discharged at the top at a temperature of 176° F.

the same size and shape, which is termed a secondary cooler. In it, brine at a temperature of about 35° F. is circulated from a refrigerating machine, and, as the milk falls over the secondary cooler, it is cooled to a temperature of about 40° F., when it may be looked upon as being pasteurised and free from all pathogenic organisms, in which state it will keep for a considerable length of time.

It is desirable that the milk should, as soon as possible after the cooling takes place, be delivered to the consumers, and be kept under cool conditions, either in bottles or in a closed vessel covered over with muslin, so as to keep out specks of germ-laden dust.

Briefly speaking, the foregoing is an outline of what is carried on in the ordinary dairy practice.

There are many modifications of this practice, such as the introduction of regenerative heaters, so as to utilise a portion of the heat of pasteurisation, which would otherwise be wasted.

In some cases, again, it is considered necessary to conduct the primary and secondary cooling over coolers furnished with mantles, so that the atmospheric bacteria which are everywhere present should be shut off from the falling milk.

Ordinarily, however, the equipment for a town's dairy consists of:

1. Steam-boiler to generate steam for pasteurising, scalding, etc.

2. Motive power, which may be either a steam-engine, gas-engine, or electric motor.

3. Refrigerating machine, which is used for supplying cold brine to the secondary cooler. In many cases it is also used for cooling a room in which the milk and cream are stored.

4. Milk-receiving tank.

5. Milk-strainer.

6. Pasteurising apparatus, and primary and secondary coolers.

Such a plant is necessary in order to conduct an ordinary town dairy business in anything like a hygienic way, and is designed only for the handling of milk intended for domestic consumption.

There are times when another plant might be necessary, such as a plant for the separation of milk, or for utilising it for the production of butter or cheese, such operations being subject to the fluctuations in the milk supply.

It is sometimes desirable also to use up an excess of milk for cheese or butter-making; hence

it is necessary to provide such apparatus as has been indicated.

Preparation of Soured Milk.—The foregoing description has been given in some detaïl, as showing the ordinary practice, and we now come to consider how it can be modified so as to provide for the production of soured milk. It may first of all be premised that within the next few years the preparation of soured milk as an ordinary production of the dairy will be universal, and will form a part of the ordinary dairy practice. The apparatus, therefore, which is necessary is one of considerable interest to all who are engaged in the dairy industry.

As will be seen from the chapter describing the preparation of soured milk in the dairy, this process can be conveniently carried on, so as to utilise the plant which is at present in general use. The milk can be received in the same way, pasteurised and cooled to about blood-heat, after which its preparation as soured milk is a very simple matter, and only requires a certain amount of careful attention.

For the keeping of soured milk, a cold room cooled by a refrigerating machine would be desirable, so as to maintain the fermented milk at a

low temperature and prevent over-fermentation.

Apparatus has been designed so as to handle soured milk on a large scale, and one of the machines is shown on the illustration (see Fig. 9). It is simply a jacketed cylinder with a cover and an agitating gear. The inside of the machine is nickel-plated, and there is an arrangement whereby the cooling may be done rapidly, through a coil inside the jacket, this coil being connected to the brine circulation of the refrigerating machine.

The machine is filled with milk containing three per cent. of fat, which has been previously pasteurised to about 190° F., and cooled down to about 90° F.; at this point the pure culture of *Bacillus bulgaricus* is introduced, and the agitator is kept working, so as to mingle it thoroughly with the milk. The agitator is then stopped until the acidity shows a test of 0.9 to 1.0 per cent., when the agitator is again started, and cold brine from the refrigerating machine is turned on to the cooling pipes, so that the product is thoroughly broken up, and cooled down to 40° F.

The milk is then transferred to a bottle-filling machine (Fig. 10), poured into bottles and hermetically sealed, after which it is ready for consumption. When it has to be kept for any time it

CONTINUOUS APPARATUS FOR THE PRODUCTION OF LARGE QUANTITIES OF SOURED MILK

FIG. 9.—This apparatus is made by the Dairy Machinery and Construction Company of Shelton, Conn., U.S.A. The milk is agitated inside a jacketed cylinder, where it is allowed to incubate at about blood heat. The milk can be rapidly heated and also rapidly cooled by means of this apparatus.

should be placed in a cold room where there is a temperature not higher than 40° F.

The process, therefore, is a simple one, and lends itself to the ordinary dairy business, without involving any great expenditure on account of a new plant.

CHAPTER V

THE BACTERIOLOGY OF FERMENTED OR SOURED MILK

A CHAPTER FOR STUDENTS

DURING the last few years much work has been done in investigating the action of various classes of organisms—bacteria, yeasts, and moulds—upon milk and its products. While, however, the attention of the dairyman has been chiefly directed to the propagation of acid-producing organisms and the use of pure cultures of lactic acid bacteria in their relation to butter and cheese making, a new sphere in micro-biology has been disclosed by the study of the effects caused by the combined growth of two or more different classes of organisms in milk and the consequent production of lactic, alcoholic, and gaseous fermentations. The simultaneous occurrence of these fermentative changes is responsible for the formation of such

beverages as keffir, koumiss, milk-wine, etc. It has therefore become essential, in connection with the study of new developments in the milk industry, that we should make a more intimate acquaintance with the bacteriology of the ferments involved.

Keffir (*kephir*, *kifyr*, *kiafyr*, *kephor*, *kyppe*) is the name given to an acid, slightly alcoholic drink, which for many centuries has been prepared by the nomadic tribes in the Caucasus. The characteristic fermentation is induced by the addition of so-called keffir grains. These are yellow or golden-yellow, warty, and furrowed flakes or nodules, the former varying in size from that of a rice grain to that of a bean, while the latter are often about an inch across and one eighth of an inch thick. Bearing in mind the fact that the preparation of keffir has been carried on for many centuries, it is not surprising that the origin of these grains should be surrounded by myths.

The belief is prevalent among the Mohammedan tribes of the Caucasus that keffir grains were, in the first instance, presented by Allah, as a sign of immortality, to one preferred tribe. Others hold that, in past ages, they were found by shep-

herds growing on a shrub in the Caucasian highlands; while, according to Skolotowski,[1] they were originally found adhering to the walls of an oaken vessel used for the preparation of airam. This is a soured milk beverage similar to keffir, but possessing a weaker alcoholic fermentation, and prepared from goats' milk by the addition of pieces of calf's stomach. This would undoubtedly serve to introduce various species of lactic acid bacteria, and will be referred to in the portion dealing with soured milks. Keffir is prepared by the Caucasians from cows', sheep's, or goats' milk, and the operation is carried on in large leathern tubes or bottles. After the addition of the grains or seeds to the milk the vessel is placed in a cool chamber, and the fermentation is allowed to proceed for one or two days, by the end of which time the normal fermentation is at an end. During this period the keffir grains have increased enormously in size, assume a bright yellow colour, and lose their sour buttery smell.

Previous to the removal of the fermented liquid, a portion of the bottle is firmly bound from the rest by a stout cord, and the greater portion of the remaining keffir is quickly removed for use,

[1] Skolotowski, *Wratsch*, 1883 (Russian), from Codwyssozki.

thus avoiding, as far as practicable, any outside infection. After the addition of fresh warm milk the cord round the end of the bottle is removed, and the old and new milk thoroughly mixed for a time in order to ensure uniform inoculation of the new milk for the next fermentation. During the winter months the leathern vessels are often placed in the sunshine, so that the temperature remains at 61° to 65° F.

The necessary agitation of the vessel is said to be supplied in the form of kicks by passers-by or by the children during their play.

The beverage prepared in this way is so gaseous in character that it is often blown forcibly from the vessel during removal, and possesses, according to Podowyssozki,[1] a very acid taste.

During any interruption in the preparation of keffir in the above manner, the grains are taken out, and after having been well washed in clean water, are spread out on a clean cloth to dry in the sunshine. They thereby assume a characteristic cheesy or buttery odour and become rather darker in colour. Thorough desiccation is essential in order to prevent subsequent mouldiness or disease of the grain.

[1] Podowyssozki, *Zeitschr. f. diät. u. physik. Therapie* vol. v., 1901, p. 570.

In European countries the grains are subjected to a preliminary soaking in water for five to six hours and then placed in four to five changes of milk, each change having a duration of two to three hours. As soon as the grains commence to rise to the surface of the milk, they may be used for the actual preparation. To this end, a small quantity of the grain is added to freshly boiled milk and allowed to stand for eight to twelve hours at a temperature of 55°–62° F. with agitation of the flask every two hours. By this time the milk, now known as Sakwaska, has become abundantly inoculated with the organisms essential to the fermentation, and after the removal of the grains, may be poured into well-corked flasks for the secondary brew. The flasks should be kept at a lower temperature for twenty-four to forty-eight hours, by which time the product is ready for consumption.

According to the temperature and length of period to which this subsequent fermentation is allowed to proceed, the resultant keffir is more or less acid and gaseous. The grains may again be used for starting a fresh portion of milk, and a regular supply obtained in this manner. Well-fermented forty-eight-hours-old keffir should be

an effervescent beverage with prickling and acid taste and a consistency and smell similar to sour cream. Large, persistent bubbles should form on the surface of the liquid and the casein be present as an extremely fine flocculent precipitate which remains suspended for a considerable time.

From the third day there ensues a gradual peptonisation of the casein. If the temperature at which the secondary fermentation has occurred should be higher than 72° F., or if the milk has not been sufficiently agitated, then the casein will be present in the form of porous small flakes, which on shaking form a fine emulsion.

The chemical changes undergone by the milk during the preparation of keffir are confined almost exclusively to the milk sugar. As already stated, a slight peptonisation occurs in old samples, but this depends very largely upon the method of preparation and purity of the culture. Hammersten[1] and Essaulow[2] show, however, that this is not a concomitant of normal fermentation. According to Hammersten, normal keffir contains—

[1] Hammersten, *Jahresb. u. d. Fortsch. d. Tierchem*, 1886, Bd. 16, p. 163.

[2] Essaulow, *Dissert. Moscow*, 1895, *Abstr.*, *Koch's Jahresb.*, 1895, Bd. 6, p. 222.

	Per cent.
Water	88.26
Fat	3.35
Casein	2.98
Lactalbumen	0.28
Peptones	0.05
Milk sugar	2.78
Lactic acid	0.81
Alcohol	0.70
Ash	0.79

In no case should the acid be higher than 1.0 per cent., and the alcohol more than 0.75 per cent.

Biology of the Keffir Grain.—The first communication on the biology of the keffir grain seems to have been made by Kern.[1] He regarded the grain as a zoöglœa composed of bacilli and yeasts, the latter being regarded as the ordinary beer yeast (*Saccharomyces cerevisseæ*), while to the former he gave the name of *Dispora caucasica.* As the name indicates, this bacillus possesses two polar spores, and germination of these proceeded in the same manner as with *Bac. subtilis.* As, however, pure cultures of the organisms were not made, and the descriptions and illustrations made by Kern fail to show any distinctive characteristics, it seems probable that accidental confusion with other organisms must have occurred.

[1] Kern, *Bulletin Soc. des Naturalistes de Moscow*, 1881, 3, p. 141.

A MILK-FILLING APPARATUS

FIG. 10.—Where soured milk is handled on the large scale, a special filling apparatus for bottles is desirable, and the soured-milk supply should be under cover as shown. This apparatus is made by the Dairy Machinery and Construction Company.

Krannhals[1] succeeded in isolating ten different keffir bacteria among which were several sporulating bacteria. Here too it is impossible to attach any importance to the results, as the artificial preparation of keffir, by means of these bacteria, was not attempted. Beijerinck[2] studied the organisms constituting keffir grains and attached prime importance to the occurrence of two organisms, viz., (*a*) a yeast, *Saccharomyces kefir*, which was capable of inverting milk sugar by means of an enzyme (lactase) and afterwards fermented the products with the formation of alcohol and carbon dioxide, and also (*b*) a non-motile non-sporulating bacterium, afterwards *Lactobac. caucasicus*. The latter, when cultivated on gelatine, gave rise to tough warty colonies about $\frac{1}{40}$ in. diameter, and was regarded as one of the lactic acid bacteria found in milk which has been incubated at 77° to 90° F. and afterwards incubated at a higher temperature, 100° to 104° F. Scholl[3] isolated three different organisms, of which a yeast inverted milk sugar for the lactic acid bacteria, while *Dispora* peptonised the albuminoid matters.

[1] Krannhals, *Deutsch. Arch. f. Klin. Med.*, 1884, Bd. 35, p. 18.
[2] Beijerinck, *Centralbl. Bakt. Par.* 1889, Bd. 6, p. 44.
[3] Scholl, *Die Milch*, Wiesbaden, 1891, p. 38.

Adametz[1] failed to isolate *Dispora*, and came to the conclusion that ordinary lactic bacteria and yeasts played the most important part in the fermentation.

Essaulow found in keffir grains six different organisms—yeast cells, cocci, short thick bacilli, bent bacilli, long threads, and motile bacteria. The two latter would seem to be *Bacillus subtilis*, while the others may be regarded as *Bacterium acidi lactici* (Hueppe), *Bacterium aërogenes*, and *Streptococcus lacticus* (Grotenfeldt). Pure cultures were insufficient to produce keffir, while mixed cultures of *Bacterium acidi lactici* and yeasts were effective.

Freudenreich,[2] to whom we owe a record of very carefully executed experiments, could not arrive at a satisfactory explanation of the rôle of *Bacillus caucasicus*. This organism is described as being 5–6 μ long and 1 μ thick, slightly motile, and possessing bright refractive spots at the poles of the bacilli. It is extremely difficult to cultivate, and forms flat, small greyish colonies of irregular outline. The bright refractive spots above referred to are, however, granules taking

[1] Adametz, *Centralbl. Bakt. Par.* 1889, Bd. 5, p. 116.

[2] Freudenreich, *Landw. Jahrb. d. Schweiz.*, 1896, vol. x., p. 1.

the usual stains quite readily, and not spores as supposed by Kern.

Freudenreich also found three other organisms —a yeast and two streptococci. The yeast, to which he gave the name *Saccharomyces* (Torula) *keffir*, forms small oval or roundish cells 2–3 μ wide and 3–5 μ long. The optimum temperature would seem to be about 72° F.; the maximum 82° F. This organism is unable to ferment milk directly, but is able to decompose maltose and glucose with gas production. It does not coagulate milk, but imparts to it a characteristic taste and is unable to withstand desiccation for more than a few days.

Of the two streptococci isolated, *Streptococcus a* resembles organisms of the group *Streptococcus lacticus* in appearance, but is able to ferment milk, with weak acid and gas production, and is capable of inducing coagulation.

Contrary to what one would expect in an organism existing in keffir grains, this streptococcus is as little able to withstand desiccation as the above-mentioned yeast. *Streptococcus b* forms smaller cells as well as smaller colonies than *Streptococcus a*, but produces more lactic acid and more gas, and retains its vitality after desiccation. The relation

of these four organisms is, according to E. von Freudenreich, as follows: *Sacch. keffir* is unable to ferment directly milk or lactose, so that its growth must be preceded by that of *Streptococcus b*. *Streptococcus a* does not seem to play this part, but, unlike *Streptococcus b*, is able to coagulate milk on its own account. By the combined action of the yeast and the two streptococci, then, milk can be coagulated, milk sugar inverted, acid and gas produced by the streptococci, while gas and alcohol are formed by the activity of the yeast. The rôle of *Bacillus caucasicus* is unknown, but it would seem to play a part in the formation of the keffir grain itself. By means of mixed cultures of the above organisms Freudenreich was successful in obtaining a fermented product possessing in all respects the characteristic properties of normal keffir. On the other hand, experiments to induce the formation of keffir grains gave negative results, but in this respect the cultural characteristics of *Lactobacillus keffir* would seem to give promise of success in the synthesis of the keffir grain. Fig. 11 is a photomicrograph of an extremely thin section through a keffir grain, after a preceding treatment with saffranin. The matrix is composed entirely

Fig. 11.—Section through a Kephir Grain—highly magnified.

of long thin bacilli (*Bacillus caucasicus*), while the peripheral portions, which are more deeply stained, consist to a large extent of dense masses of yeast cells with occasional streptococci. In a normal grain the latter organisms are present on the surface or in the cavities and grooves of the grain, and only to a less extent in the matrix. Nikolaiewa[1] claimed to have isolated a hitherto unknown bacillus capable of coagulating milk by acid production, *Bacterium caucasicum*, not identical with, but related to Freudenreich's *Bacillus caucasicus*, and also a torula. Although no experiments were carried out, Nikolaiewa asserts that this organism forms the matrix of the grains. He was able to produce a beverage resembling keffir, just as Freudenreich and Essaulow did with entirely different organisms, but his product would appear to have been slightly too acid and to have lacked the characteristic aroma of the normal product. In the course of an extensive series of experiments Kuntze[2] found the following organisms:

(*a*) True lactic acid forming bacteria, *Streptococcus acidi lactici* (Grotenfeldt).

[1] Nikolaiewa, *Annals of the Botan. Lab. of the Med. Inst. for Women*, No. 10. St. Petersburg, 1907.

[2] Kuntze, *Centralbl. Bakt. Par.* 1909, 24, p. 101.

(*b*) Bacteria of the group *Bacterium acidi lactici* (Hueppe) and *Bacterium lactis aërogenes*.
(*c*) Various torula and yeast species.
(*d*) Two species of butyric acid bacteria, *Bacillus esterificans* and *Bacillus keffir* (Kuntze).

His conclusions are: 1. In any case the presence of a yeast capable of directly fermenting milk sugar is not essential. 2. The significance of the presence of yeast lies in the fact that stimulation of the lactic bacteria occurs; further, the yeast exerts a regulating influence upon the rapidity of the fermentation proper. The variety is of minor importance, provided always that the yeast does not produce an unpleasant flavour. By the use of mixed cultures of *Bacillus esterificans*, *Bacillus keffir*, and *Streptococcus acidi lactici*, and a keffir yeast, Kuntze obtained a product that possessed to the fullest degree all the characteristic properties of a normal keffir. In such cultures he was successful in obtaining the formation of keffir-like grains. Keffir fermentation is, according to Kuntze, the result of the action of various organisms. During the initial stage butyric acid fermentation takes place, but is prevented from becoming predominant by the action of the keffir yeast. Simultaneously a true lactic acid fermentation proceeds and eventually gives place to a sub-

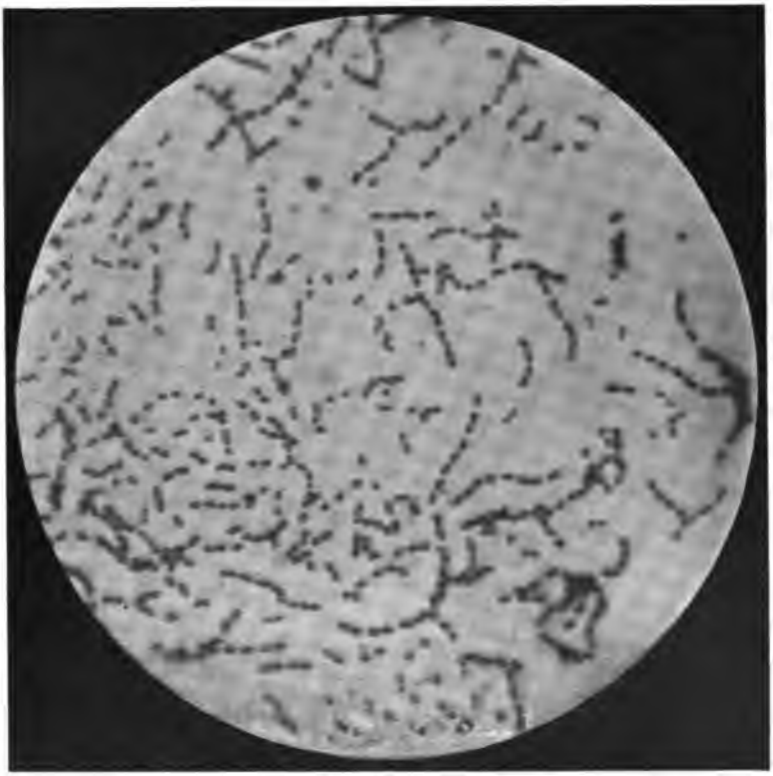


Fig. 12—***Streptococcus lacticus*** **(Grotenfeldt) growing on lactose-agar, stained by Gram's method. (× 900 diams.)**

sequent secondary production of butyric acid. Finally, then, we have a certain amount of unison in the results obtained by Freudenreich, Essaulow, Nikolaiewa, and Kuntze. These show that, for the production of a characteristic keffir, specific organisms are not essential, provided always that those used possess, either individually or collectively, the essential capacity of acidifying, coagulating, and fermenting the milk. For the growth of normal grains the presence of a matrix-forming organism, such as *Bacillus keffir*, is indispensable.

Diseases of Keffir Grains.—According to the age and the previous treatment to which keffir grains have been subjected, the vitality of one or more of the organisms constituting the grain may have been impaired. The results of Freudenreich have shown that *Saccharomyces keffir* and *Streptococcus a* are unable to withstand desiccation for more than a few days, and this is sufficient to account for the frequent failures to obtain normal keffir from the grain. Further, grains succumb to a mucilaginous disease; the cavities become filled with a slimy fluid, and the grains are covered with mucilaginous matter. They lose their elasticity and become brittle or mealy, but large grains appear to be more subject to this fault than do

the small ones. Such grains should be disinfected by immersion for a short time in two per cent. salicylic acid solution, followed by drying in the sun, whereby they are completely regenerated.

Another disease consists in the predominance of certain butyric acid bacteria which impart an unpleasant rancid taste to the keffir (Podowyssozki). This is generally attributed to the use of rich milk, or too high a temperature during preparation.

Koumiss.—Another product of the combined action of lactic acid and alcohol-producing organisms is called koumiss, kumys, milk-wine, lac fermentation, or vinum lactis. In the steppes of Southern Russia and Asia, as we have seen,[1] it is prepared chiefly from mares' milk, but occasionally from that of camels and jennets. The name is said to be derived from that of a tribe mentioned by Xenophon and Pliny, viz., the Kumanen, by whom its preparation was practised. After the war with the Tartars in 1215 its use was adopted by the latter people, and eventually spread to the Turkomanen, Kalmucks, Khirgiz, Mongolians, etc.

Rubruck, in 1253, records the use of a fermented drink—kosmos—prepared from mares' milk, and

[1] See Chap. II.

about the same time Marco Polo mentions the occurrence of a milk-wine, chumis or chemius, among the Tartars. The fact that the Tartars were seldom ill, and were almost invariably free from lung troubles, led to an influx of visitors from surrounding countries, until finally its use spread to Russia, Austria, and Germany. At the present time the best koumiss is that produced in the province of Orenburg; but specially equipped koumiss establishments, under the control of physicians, exist in Odessa, Samara, Ufa in the Urals, and other districts. The curative properties of koumiss have long been recognised and its use is indicated in cases of indigestion, chlorosis, scurvy, tuberculosis, etc.

Rubinsky states that, among the nomadic tribe, of Khirgiz and Kalmucks, a special leathern bottle (Turssuk, Orroth, or Soaba) is used for the preparation of koumiss, while wooden tubs (Tschiljak) similar in shape to the old-fashioned churn are used by the Bashkirs, and in koumiss establishments.

The fermentation is induced by the addition of koumiss to fresh mares' milk, in proportions which vary according to the cleanliness observed in the actual preparation. Where the process

is carefully controlled, one part of koumiss to ten parts of milk is often used, but where gross infection from outside sources takes place one part of koumiss to three parts of milk is taken. The mixture is stirred at frequent intervals, and stored at a temperature of 73°–90° F. Weak koumiss is obtained after twenty to twenty-four hours in winter and twelve to fourteen hours in summer, but is scarcely ever consumed immediately, as it possesses a strong purgative action.

It is generally poured into bottles (bottled koumiss); or allowed to remain in the tubs (tschiljak koumiss); in the former case the fermentation is anaërobic, in the second it is aërobic.

Storage of the koumiss upon ice or in a cellar is necessary since medium koumiss is converted to strong koumiss in twelve to sixteen hours at ordinary temperatures, while at the lower temperature this occurs only in two to four days.[1]

According to Biel,[2] either old koumiss or the dried sediment from old koumiss may be used for the initial inoculation. It may also be prepared by the repeated inoculation of mares' milk with soured cows' milk until a fermenting product is

[1] Rubinsky, *Centralbl. Bakt. Par. II.*, 1910, vol. xxviii., p. 161.
[2] Biel, *Jahresb. ü. d. Fortschr. d. Tierchem*, 1886, 16, p. 159.

obtained. Koumiss may be prepared by a method stated by Allik[1] to be in general use in the Caucasian health-resorts. One part of beer-yeast is added to four to ten parts of fresh mares' milk (according to the strength of product required), and after thorough mixture of the two liquids the whole is allowed to ferment at a temperature of 70° to 72° F. for two days. One part of this first product is then added to five parts of fresh cold milk, and allowed to stand three to four hours at 75° to 77° F. It is then poured into bottles, and after the expiration of another three to four hours is stored away in a cellar at about 45° F. This koumiss may be used at any time from one to five days (generally two to three) after bottling according to the strength desired or prescribed in each individual case.

The changes undergone during fermentation consist in a vigorous gas and acid production accompanied by alcohol formation and coagulation of the milk. The coagulum exists in an extremely fine state of division, and the liquid froths violently on the bottle being opened. It has a full pleasant acid taste, but should not contain more than one per cent. acid and two per cent. alcohol. The

[1] Allik, *Dissertat. Dorpat.*, 1896, 19, p. 303.

specific gravity of koumiss is 1.008 to 1.020 at 60° F. Appended is an analysis of two different samples of koumiss:

	Prepared from	
	Mares' Milk.	Separated Cows' Milk.
	Per Cent.	Per Cent.
Water	91.535	88.933
Fat	1.274	0.854
Nitrogenous bodies	1.913	2.025
Sugar	1.253	3.108
Ash	0.293	0.444
Carbon dioxide	0.876	1.027
Alcohol	1.850	2.647
Lactic acid	1.006	0.796
Glycerine	...	0.166

Fleischmann[1] gives a formula for preparing an artificial koumiss from separated cows' milk, water, cane sugar, and milk sugar, with the addition of distillery yeast. Needless to say, this product must possess some of the characteristic by-flavour of the yeast employed, and is less suitable than koumiss prepared by the aid of a lactic yeast. Schipin investigated the fermentation of koumiss and found three distinct organisms.

Rubinsky in a recent article threw much light on the phenomena of koumiss fermentation.

[1] Fleischmann, *Lehrb. d. Milchwirtschaft*, 2d edition. Bremen, 1898.

According to him, koumiss contains almost invariably four different organisms, viz., koumiss yeast, koumiss bacterium (*Lactobacillus*), *Streptococcus lactis* (Lister), *Bacterium aërogenes*, and occasionally *Bact. caucasicum* (Nikolajewa). For the preparation of normal koumiss only the two former organisms are required; they exceed in number any of the other organisms whose presence in the dairy is unavoidable. The presence of the two latter organisms is favourable to the production of good koumiss, as, by inducing a preliminary lactic fermentation, they tend to inhibit the growth of undesirable extraneous bacteria, etc. In medium and strong koumiss they die out on account of the amount of lactic acid formed (1%).

Koumiss yeast possesses strongly differentiated protoplasm, but lacks any cultural characteristics. Abundant growth occurs in milk, and lactic acid (0.3%), alcohol, carbon dioxide, albumens and peptones, volatile acids, and aromatic substances are formed.

Koumiss bacterium is related to the *Lactobacillus* of various other fermented milks, and is similar to *Bac. acidophilus*, and possesses like these a distinct polymorphism (branched cells, long and

short bacilli, etc.). It is non-sporogenous, has an optimum temperature of 90° to 97° F., and possesses cultural characteristics similar to those of the rest of the *Lactobacilli.*

The by-products of koumiss yeast appear to favour the growth of the koumiss bacterium, as this organism, like the other *Lactobacilli,* is favourably influenced by the presence of small quantities of peptone, alcohol, and acid.

The organisms found by Schipin consisted of a species of *Saccharomyces* and two bacilli, *Bacillus acidi lactici* and a non-sporulating bacillus. The latter organisms coagulate milk at 98° F., but not at room temperature, and although a minute description of cultural characteristics is not given it would seem to be related to *Bacillus* or *Lactobacillus caucasicus.*

Leben Raïb or *Leben* (*Laban*).—This is a beverage prepared largely by the Egyptians, and differs from keffir, as does matzoon, in possessing a characteristic aroma and taste. It differs also from the former by having only a very weak alcoholic fermentation, and by the coagulum being coarse and lumpy instead of being extremely fine. It is made from buffaloes', goats', or cows' milk by the addition of roba (or old leben) to the

previously boiled and cooled fresh milk. The use of leben is many centuries old, and it is used in Egypt as in Arabia for medicinal purposes, although that of the Syrians and Arabians is said to differ from that of the Egyptians and Algerians. The fermentative changes occurring in the formation of the Egyptian leben have been investigated by Rist and Khoury,[1] and also by Guerbet,[2] who found that five organisms were normally present. These comprised a chain-forming bacillus (*Streptobacillus*), a second smaller bacillus (*Bacillus lebenis*), a diplococcus, a saccharomyces, and a mycoderma. Of these five organisms, it would appear that four live in metabiosis, the streptobacilli and bacilli hydrolyse the milk sugar, the components of which are split up by the yeast to alcohol and carbon-dioxide. The alcohol thus formed, together with the glucose formed by hydrolysis, are eventually converted to acid or combusted by the mycoderma species. The leben thereby assumes the sharp, unpleasant flavour met with in old samples. The diplococcus merely produces acidification and coagulation of the milk. Rist and Khoury were able, by the use of these

[1] Rist and Khoury, *Annal. Pasteur*, 1902, 16, p. 65.
[2] Guerbet, *Comptes Rendus*, 1906.

organisms, to produce normal leben, especially when the true yeast was allowed to grow in the milk' for some time before inoculation with the other organisms was made.

Some of the half-civilised tribes of Siberia, the Tartars and the Burgaten, prepare a strong alcoholic beverage, arakà or ojràn, from fermented milk. This is really a product of distillation, and contains seven to eight per cent. of alcohol and volatile fatty acids.

Matzoon.—This is a drink used largely in Western Asia, and is similar in character to keffir, but has a peculiar taste which distinguishes it from all other fermented milks. According to Weigmann,[1] it is prepared from buffaloes', goats', or cows' milk, and is used partly as a means of souring milk for butter-making and also as a lactic food, eaten with spoons. In the same way buttermilk produced from milk which has been previously ripened by matzoon is used as a beverage. Finally, the coagulum (*than*) of such buttermilk is strained off, and, after being pressed, is mixed with meal and dried by exposure to the sun's rays. The preparation of matzoon is in many

[1] Weigmann, *Lafar's Handb. d. Techn. Mykol.*, 2d edit., 1905, vol. ii., p. 134.

FIG. 13.—Photo-micrograph of preparation from Armenian soured milk (Matzoon). This is related to Yoghourt, and contains, as will be seen from the above photo, yeasts, streptococci, diplococci, and a bacillus with the morphology of ***Bacillus bulgaricus***. This, and similar foods, owe their peculiar properties primarily to the presence of ***Bacillus bulgaricus*** (type A, White and Avery), and only in a lesser degree to the yeasts and lactic streptococci.

respects very similar to that of keffir and koumiss, but differs by inducing a comparatively weak alcohol fermentation. In common, too, with yoghourt, the prevailing temperature is much higher than is required for keffir and koumiss.

In regard to the biology of matzoon, the occurrence of various organisms has been recorded. Emmerling[1] isolated, in addition to a yellow pigment-forming organism, *Bacillus subtilis*, *Bacillus lactis acidi*, and several fungi, a small micrococcus capable of hydrolysing milk- and cane-sugar. The organism produces and without gas formation, or peptonisation of the medium. Of the nine yeasts isolated from matzoon by Lindner[2] and Kalantharianz,[3] three were able to ferment milk sugar without previous hydrolysis, while two others, by the simultaneous production of lactic acid and fruit esters, gave to the matzoon its characteristic taste and aroma.

Yoghourt and Soured Milk.—Yoghourt is another fermented milk, and is related to the matzoon of Armenia, the gioddu of Sardinia, and the leben of Egypt. After a preceding boiling and reduction

[1] Emmerling, *Cent. Bakt. Par.* 1898, vol. iv., p. 418.

[2] Lindner, *Mikroscop. Betriebscontrolle, i. d. Gärungsgew*, 3d edit., Berlin, 1901.

[3] Kalantharianz, *Dissert. Berlin*, Abs. in *Koch's Jahresb.*, 1898, Bd. 9.

of the volume of the milk, inoculation of the mass is made by the addition of a small quantity of old culture, and it is then allowed to sour at a comparatively high temperature. A moderately compact, jelly-like coagulum is thus formed, while keffir and koumiss possess a liquid consistency. The fermentation necessary for the two latter products only proceeds, too, at a much lower temperature, at which yeasts play an important part. According to Guerbet, yoghourt incubated for ten hours at 113° F. contained 0.34 per cent. lactic acid and 0.012 per cent. alcohol. Luerssen and Kühn[1] came to the conclusion that yoghourt contained chiefly a mixture of *Bacillus bulgaricus*, diplostreptococci, and a "granule" bacillus, so called on account of its granulated appearance after treatment with methylene blue. According to these authors, the first two organisms were found in each of eight samples of maya (young yoghourt) and of yoghourt itself, but the occurrence of the "granule" bacillus in plate cultures was by no means regular. In addition, yeasts were found in almost every sample examined, but were regarded more as accidental infections rather than as essential to the formation of a typical product.

[1] Luerssen and Kühn, *Centralbl. Bakt.*

The combined action of the three organisms already mentioned gave rise to a product closely resembling normal yoghourt. Piorkowski[1] subjected Bulgarian maya to examination and associated himself with Metchnikoff[2] in finding three species, a streptococcus, a diplococcus, and a specific organism to which he gave the name *Yoghourt bacillus*. Similar results were also obtained by Grigoroff.[3] Piorkowski's *Yoghourt bacillus* is similar in form to *Bacillus subtilis*, but does not sporulate, nor does it liquefy gelatine. Young individuals are stained by Gram's method; older individuals are, however, Gram negative. The optimum temperature is 112° F. Kuntze attempted to isolate the organisms mentioned by Luerssen and Kühn, and by plate culture procured growth of a spore-forming bacillus similar to Weigmann's *Bacillus matzoon*. To this organism is attributed the power to impart a specific taste to the matzoon, but as growth is comparatively slow, it can only be of significance in determining the quality of the curd and cheese prepared from this product. Cultures were also obtained which resembled in general character those of the organism described

[1] Piorkowski, *Sitzungsber. der Berl. med. Ges.*, Nov., 1907.
[2] Metchnikoff, *The Prolongation of Life*.
[3] Grigoroff, *Revue Médicale de la Suisse Romande*, 1905, p. 10.

by Luerssen and Kühn as *Bacillus bulgaricus* and named by Kuntze *Bacterium W*. Granule formation was transient in this culture, and the organisms eventually became inactive. Further analysis of maya gave cultures of the "granule" bacillus, but these passed over from the type forming irregular colonies (see Figs. 14, 15, 16) to that producing smooth colonies. Further, although the granule formation persists largely in milk, the organisms soon revert to the non-granular type if cultivated on agar. By the use of the Gram-Weigert stain organisms from a several-days-old culture on beer-wort-agar gave an interesting reaction. The bacillar threads are in places Gram-negative, in others Gram-positive, and bear small club-like swellings (see Fig. 14). Results similar to these were also obtained with cultures of *Bacillus matzoon* (Weigmann and Grübner) and also with *Bacillus acidophilus*.

Neisser's method of staining failed to give such good effects by the examination of fresh maya, as did an alcoholic aqueous solution of methylene blue in showing up the granules of the organisms. Again, Grixoni[1] found, but did not isolate, a similar granule-forming organism (*Bacterium sar-*

[1] Grixoni, *Abstr. Cent. Bakt. Par.* 11, 15, p. 750.

[This group of sixteen illustrations (Figs. 14 to 29), showing various aspects of the Yoghourt bacillus and others of a cognate nature, is taken from the *Centralblatt für Bakteriologie* of Jena.—L. M. D.]

FIG. 14. — Granule Bacillus from Yoghourt. Shredded preparation of a fresh skim-milk culture at 37° C. for six hours. Stain: aqueous methylene blue. (Enlarged 1:500.) In Figs. 15 and 17 will be noticed the chain arrangement of the bacillus, which, in spite of the supposed data of Luerssen and Kuhn, will be generally noticed in the granule bacillus.

FIG. 16.—Granule Bacillus from Yoghourt. Agar Milk Sugar Culture cultivated for forty-eight hours at 37° C. Below is the true branching, above, the distorted involution form. This production of involution forms occurs chiefly in old cultures, and is an indication of degeneration. Stain: aqueous methylene blue. (Enlarged 1:700.)

FIG. 15.—Granule Bacillus from Yoghourt, cultivated after the usual Agar method, for twenty-four hours at 37° C. Stain: aqueous methylene blue. (Enlarged 1:500.)

FIG. 17.—*Bacteria W.* from Milk, cultivated twenty-four hours at 37° C. Methylene blue. (Enlarged 1:500.) The similarity in the pictures ought to serve as a proof of the near relation of the granule form and non-granule varieties.

dous) in Sardinian gioddu. As already mentioned in the description of leben, Rist and Khoury found a long bacillar lactic ferment (*Streptobacillus lebenis*) which also exhibited the irregular greyish white hairy colonies and high optimum temperature characteristic of this group. On account of the similarity in form, staining reactions, temperature requirements, and cultural growth of the organisms described by Emmerling, Düggeli, Weigmann, Grixoni, and Rist and Khoury, Kuntze is inclined to regard them as belonging to one single group of lactic ferments. According to him the granule formation is rather variable, and may be induced or suppressed by cultural methods. Not only do organisms of this group produce far more acid than the normal lactic bacteria; they are also more resistant to acid, and are able to develop in milk to which 0.5 per cent. hydrochloric acid has been added. A comparatively high percentage of alcohol seems to encourage growth, and this was obtained in milk containing 4 per cent. alcohol. This would no doubt tend to explain the phenomenon observed by Kuntze that milk is not so rapidly fermented by organisms of this group as when cultures of diplococci and yeasts are added. Since organisms of this group would

seem to be widely distributed, the question of their natural habitat arises. Luerssen and Kühn were unsuccessful in their search for such organisms in Königsberg milk, but Leichmann records the occurrence of a long bacillus (*Bacillus lactis acidi*) in milk that had spontaneously soured at 112° to 120° F. This organism, too, showed characteristic growth on agar media, and produces lævo-rotatory lactic acid. The examination of calves' stomachs showed, according to Kuntze, only occasional long bacilli, but inoculation of sterile milk and incubation at 100° F. with repeated over-inoculation gave a culture showing the characteristic granule reaction (see Figs. 18 and 20). Although plate cultures made direct from calves' stomachs do not exhibit the regular contours generally shown by the granule bacillus, yet this growth may be induced by preceding cultivation in lactose bouillon to which 0.5 per cent. acetic acid has been added. A similar organism, *Bacillus acidophilus*, was isolated from calves' manure by means of this acetic bouillon, as was also a diplostreptococcus which resembled very closely the typical lactic acid streptococcus. This resemblance was made all the more striking by the fact that they were capable of coagulating milk at a

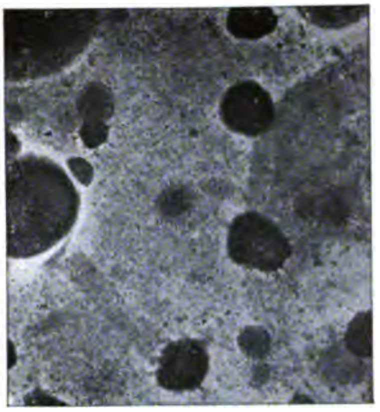


FIG. 18.—Agar Milk Sugar Culture. From the original Bulgarian Yoghourt. In the centre, and beneath, the characteristic hairy irregular colonies of the granule bacillus (*Bacillus bulgaricus* group), to the left, the smooth contoured yeast colonies. The colonies of the former organism always remain microscopic in size. (Incubated several days at 20° to 25° C. Magnified × 10.)

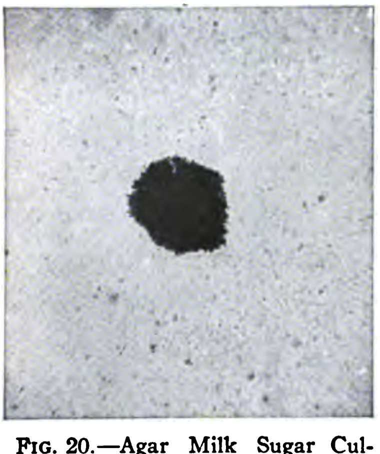


FIG. 20.—Agar Milk Sugar Culture. Deep-lying colony of granule bacillus from calf's stomach. The form of the colony is often determined by the relative presence or absence of air. (Two days at 37° C. Enlarged about 1:50.)

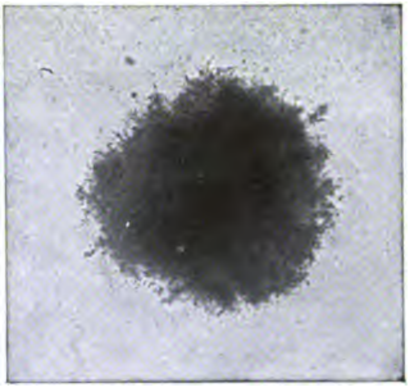


FIG. 19.—Agar Milk Sugar Culture. Surface colony of granule bacillus from calf's stomach. The great resemblance this colony bears to those formed by the granule bacillus from Yoghourt will be apparent. This fact, as well as close agreement in other cultured features, induced Küntze to place these organisms in one group. (Incubated two days at 37° C. Magnified × 100.)

FIG. 21.—Agar Milk Sugar. Colony of *Bacterium W.* from Yoghourt (non-granular variety of the granule bacteria, as far as possible identical with Luerssen and Kuhn's *Bacillus bulgaricus*), of a cubical branching-out form.

According to Küntze, the granule formation of this and related organisms is variable, while White and Avery regard it as a constant characteristic. (Incubated two days at 37° C. Magnified × 50.)

temperature of 99° to 104° F. Since these organisms are present in large numbers in manure and also in the digestive tract of ruminants, it would seem probable that their occurrence is not without significance for the operations of cheese manufacture. According to Jensen, the practice of applying farmyard manure to Swiss meadows has been regarded as absolutely essential to the production of cheese of the best quality; while, on the other hand, the application of artificial manures would seem to have been responsible for an increase in abnormal cheese. Kuntze found further that by the combined inoculation of sterile milk with the diplostreptococcus and the "granule" bacillus from calves' stomachs, together with a yoghourt yeast, he was able to obtain a product possessing a taste and aroma little different from normal yoghourt. During their investigations upon the ripening of Swiss hard cheese, Freudenreich and Jensen[1] isolated five varieties of lactic acid bacilli, and were able to show that one of these, especially *Bacillus casei* ε, was of the greatest importance for the production of good cheese. This organism has been found by Thöni to be present in rennet tablets, while

[1] Freudenreich and Jensen, *Cent. Bakt. Par.* II, 1897, 3, 545.

a related variety, *Bacillus casei δ*, was found in fresh calves' stomachs. Unfortunately, staining tests with these organisms were not carried out, so that no data are available in regard to the presence of granules. The photo-micrographs of these organisms show the small clubs and true-branched forms. The presence of these diplococci and bacillar lactic ferments in the intestinal tract of ruminants and horses might possess some importance for the preparation of yoghourt in bags or tubes made from the stomachs of these animals. Finally, Moro[1] has isolated an acido-philic organism from the dejecta of infants which resembles closely, both in manner of growth, resistance to acids, true branching, and temperature optimum, the granule bacillus and related forms.

In a review of the literature of the subject of soured milks, Makrinoff suggests the adoption of the two names, *Streptobac. lebenis viscosus* and *Streptobac. lebenis non-viscosus*, for the organisms of the so-called Bulgaricus group, and known at present as *Bacillus-bulgaricus*, *Streptobac. lebenis*, *Bacillus of Massol*, *Granule bacillus*, *Bact. Mazun*, *Bac. lactis acidi*, etc.[2]

[1] Moro, *Wien. klin. Wochenschr.*, 5, 1900.

[2] Makrinoff, *Cent. Bakt. Par.* II, 1910, vol. xxvi., p. 374.

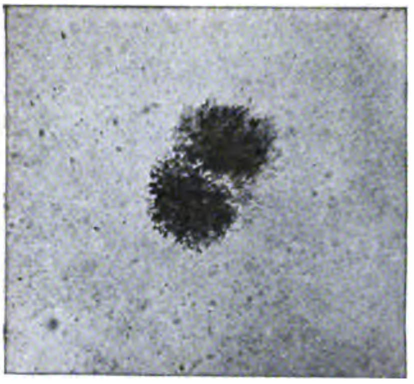


FIG. 22.—Two colonies of *Bacillus acidophilus* from calf's manure. Agar Milk Sugar Culture. With this organism, also, we have conformation to one type of colony, while, in other respects, temperature requirements and production, etc., we have close agreement with the granule bacillus (*Bacillus bulgaricus*). (Two days at 37° C. Enlarged about 1:50.)

FIG. 23.—Beer-wort Gelatine. Fourteen-days-old colony of Yoghourt yeast. (Enlarged about 1:50.)

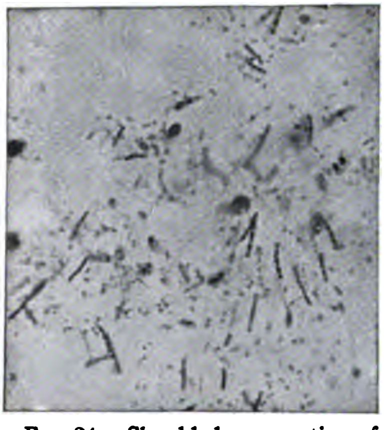


FIG. 24.—Shredded preparation of the Bulgarian original Yoghourt. Stain: aqueous methylene blue. Granule bacillus, diplostreptococci, and yeast. (See also other photomicrographs of Yoghourt. Enlarged 1:70.)

FIG. 25.—Granule Bacillus from Yoghourt. Cultivated in skim milk in twenty-four hours at 37° C. Stain: aqueous methylene blue. (Enlarged 1:50.)

By means of this staining treatment the presence of granules (not spores) can be easily detected. Treatment with fuchsine fails to bring out these formations.

White and Avery[1] have made a comparative study of a large number of varieties and species of lactic acid bacteria of the above type obtained from various fermented milks and milk tabloids. Their descriptions are so detailed and their conclusions are so important that we give them at length. According to this work, the whole of the thermophilic lactic acid bacilli of the so-called Bulgaricus type may be divided into two subtypes, A and B.

The Cultural Characteristics of the Bacillus Bulgaricus Group

The cultural characteristics of all the strains of *Bacillus bulgaricus* (granule bacillus) are as follows:

In Whey Agar.—All strains exhibit wide variation in size, 2 μ to 50 μ long and about 1 μ broad. Almost all individuals are intensely Gram-positive, and show regularity of outline. All strains show involution form, exhibiting vacuoles, and often show empty cell membranes. The latter are Gram-negative, and vary greatly in both dimensions as well as in form. All strains show tendency to chain formation, some being arranged

[1] White and Avery, *Cent. Bakt. Par.* 11, 1909, vol. xxv., p. 161.

in chains of six to twenty-five segments, which may contain both Gram-positive and Gram-negative individuals. Type B exhibits Gram-negative spherical bodies varying from 0.25 μ to 1 μ in size, adhering to the sides of some of the Gram-negative individuals.

In Whey.—In this medium there is a marked tendency toward degeneration and involution. In the early stages of incubation, at 100° to 112° F., the bacilli are uniform in size and intensely Gram-positive; in succeeding stages the irregular, vacuolated, inflated, and ruptured forms predominate. Between the eighteenth and twenty-fourth hours of incubation at 112° F. the strains of type A develop oval to kidney-shaped nodules attached to a stem extending from the cell substance. As the incubation is prolonged these nodules increase in size, often measuring 1μ to 2μ in length; this nodule formation occurs at the expense of the cell protoplasm, and appears to be a marked characteristic of growth in whey. Cultures of type B do not form nodules or clubs, but small spherical bodies more or less securely attached to the cell wall are seen. Again, type A assumes the form of small bacilli in chains, while type B strains develop to a greater length and

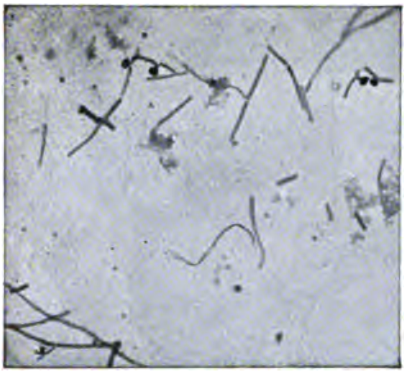


FIG. 26.—*Bacteria W.*, Agar Milk Sugar Cu ture. Cultivated twenty-four hours (knobs, clubs). Stain : Gram's method coloured with aqu ous fuchsine afterwards. (Enla ged 1:600.)

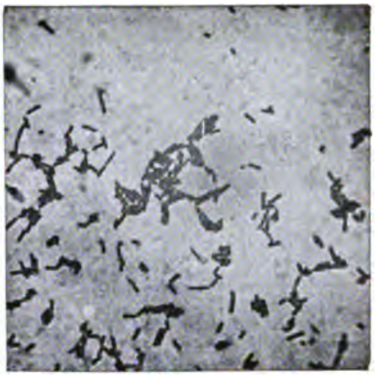


FIG. 27.—*Bacteria acidophilus* from calves' manure, isolated by means of bouillon as acid as vinegar. Shredded out of the usual Agar culture. Twenty-four hours at 37° C. Stain: aqueous methylene blue. (Enlarged 1:700.)

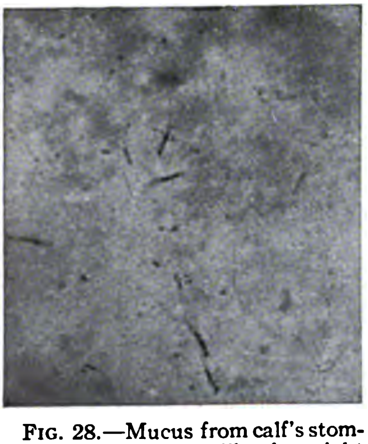


FIG. 28.—Mucus from calf's stomach inoculated into milk after eight transferrings. Shredded preparat on cultivated in milk for twenty-four hours at 37° C. Diplostreptococci and granule bacillus. Stain : aqueous methylene blue. (Enlarged 1: 500.)

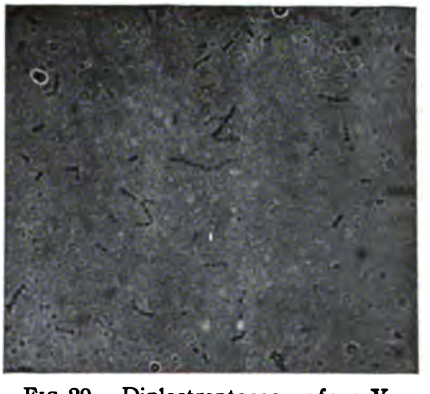


FIG. 29.—Diplostreptococcus from Yoghourt. Pure culture in skim milk. A comparison of the illustrations will show how close a resemblance exists between bacteria found in the mucous membrane of calf's stomach and those occurring in Yoghourt. In fact, by the combined action of granule bacilli, and of diplostreptococci from calf's stomach, together with a Yoghourt yeast, it is possible to prepare normal Yoghourt.

exist almost exclusively as single isolated forms. True branching has been observed in strains of type B.

In Milk.—In milk there is a tendency to thread-formation consisting of four to ten segments in the case of type A, while type B shows longer and more curved forms. With increasing age of the culture there also appears to be increase in the length of the organisms. All strains are non-motile, non-sporogenous, and non-capsule-forming.

Staining Reactions.—All strains are readily stained by the usual aniline dyes.

A. Gram's Method.—Young individuals give an intense reaction with this stain; old bacilli are easily decolourised, and degenerate forms are always Gram-negative, while single individuals have been observed which showed gradation from one pole of the cell to the other.

B. Loeffler's Methylene Blue.—According to the behaviour of the organisms studied, a separation into two types appears possible, type A being uniformly impregnated, while type B shows distinct differentiation. The cell body is seen to contain a varying number of round to oval bodies or granules. This is the appearance already

mentioned by Düggeli, Luerssen and Kühn, and Kuntze, and from which the granule bacillus derives its name. In opposition to the observations of Kuntze, the occurrence of granules was not found to be variable; it was, indeed, so constant as to constitute a distinguishing characteristic between the two types. The organisms of this group are difficult to cultivate, and freshly isolated growth is obtainable only on media containing whey, malt, or in milk. They grow equally well under aërobic or anaërobic conditions. The optimum temperature for growth is 113° to 115° F.; growth is fair at 85° F., slight at 75° F., and does not take place at 68° F.

Colonies on whey agar are round to irregular, greyish white, curled and filamentous, often streaming, and in a few cases smooth and even in structure. Gelatine is not liquefied. There is no surface growth on gelatine stab-cultures. Along the stab the growth is filiform, beaded, with subsequent horizontally projecting ramifications. Milk is coagulated in eight to eighteen hours at 112° F., and is the most favourable medium for growth.

Type A produces 2.7 per cent. to 3.7 per cent. inactive lactic acid in milk, while type B produces

[I am indebted for this group of illustrations (seventeen in number) to the editor of *Bacteriotherapy*, New York, U.S.A.—L. M. D.]

FIG. 30.—Photo-micrograph of preparation made from Yoghourt, showing yeast cells, large lactic diplococci, small slender bacilli, and many large bacilli possessing the morphology of *Bacillus bulgaricus*. Yeast cells are almost invariably found in native Yoghourt, but do not appear to be essential to the production of a tropical beverage. Indeed, they would seem to be responsible for the unpleasant astringent taste often met with in old samples of this product.

FIG. 31.—Photo-micrograph of smear from Greek Curdled Milk called "Giaourti," and showing yeast cells, long bacilli, and a mould (*Oidium lactis*), possessing very large elongate cells. The presence of the latter is very undesirable, as it rapidly combusts the lactic acid, digests the casein, and imparts a strong unpleasant cheesy flavour to the beverage.

only 1.2 per cent. to 1.6 per cent. lævo-rotatory lactic acid in milk. There is a small quantity of acetic, formic, and succinic acids formed. The conclusions of White and Avery are:

I. A review of the morphological culture and biochemical features of the lactic acid producing bacilli from yoghourt, matzoon, and leben, appears to justify their classification as a single group.

II. This group would seem to be identical with *Bacterium caucasicum* (Kern).

III. The significant variations exhibited by these bacilli in regard to the presence or absence of granules demonstrable by differential stains, the degree of lactic acid production, and the nature of the acid produced, suggest a division into two different types—the true type A, and the paratype B.

Quite recently Hastings and Hammer[1] recorded the isolation from milk of an organism producing more acid than either *Bacterium coli commune* or *Bacillus lactis acidi*. It is characterised by possessing a high optimum temperature, and by the limited conditions under which it grows on nu-

[1] Hastings and Hammer, *Research Bull., Wisconsin Experimental Station*, 6, 1909.

trient media. On this account these investigators suppose it to be related to those described in the paragraphs on fermented milks, leben, matzoon, etc., and which are regarded by Kuntze as being identical.

Similarly Boutroux[1] found 1.5 per cent. acidity produced in a solution containing albuminous matter and glucose; while Richet[2] states that with the addition of gastric juice to milk as much as four per cent. acidity may be formed. After storing samples of milk for eight days at 100° F., Koning[3] found 2.35 per cent. and 2.5 acid; while similar samples stored at 60° to 62° F. for the same period only developed 0.9 per cent. Heinemann[4] records the production of 3.0 per cent. acid in milk incubated at 100° F.; and Jensen states that *Bacillus casei* ε is capable of developing 2.7 per cent. lactic acid.

Dr. H. B. Hutchinson, bacteriologist at Rothamsted Experimental Station, has also been successful in isolating a bacillus from English market milk resembling in every particular those classified by White and Avery as type A.

[1] Boutroux, *Comp. Rend.*, 86, 1905, 605.
[2] Richet, *Comp. Rend.*, 86, 1905, 550.
[3] Koning, *Milchw. Zentralbl.*, 1905, 1, 280.
[4] Heinemann, *Centralbl. Bakt. Par.* 1908, 21, 57.

FIG. 32 is a photo-micrograph of soured milk inoculated with a tablet containing viable and pure cultures of *Bacillus bulgaricus*, and incubated for seventy-two hours. These tablets constitute a valuable means of preparing soured milk for therapeutic purposes.

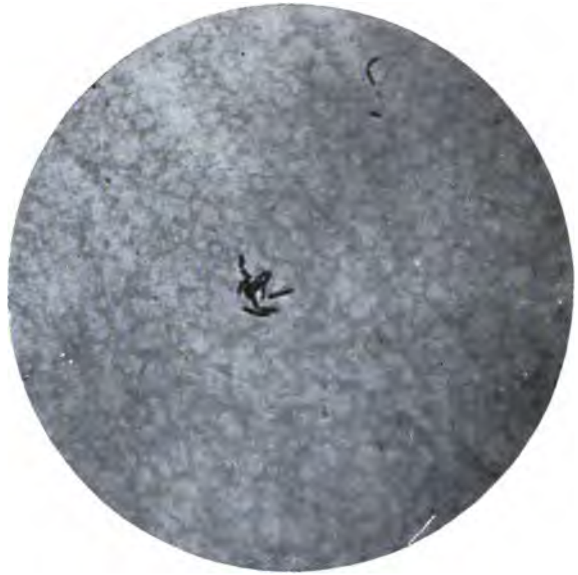


FIG. 33 is a photo-micrograph of milk inoculated with a ferment tablet in which *Bacillus bulgaricus* is no longer viable, and the only growth obtained is that of an organism allied to the *Bacillus subtilis* (Hay bacillus) group. Such milk would be absolutely without value.

It will thus be seen that organisms related to those of Oriental and Occidental milk beverages are present in conditions where it is impossible for them to attain to any active growth. The same class of organism has also been found in many cases in butter and cheese throughout the United States.

Of recent years the consumption of milk fermented by these organisms has been introduced more or less successfully into all European countries. This custom is due, as we have seen,[1] to a very great extent to the announcement of Metchnikoff[2] that the action of such organisms in the alimentary tract conduce to a prolongation of life. Moro found that the dejecta of children contain large numbers of *Bac. lacidophilus* and *Bac. bifidus*, but, as age advances, the bacterial flora of the intestines tends to change. The number of acid-producing organisms gradually becomes less, and other bacteria capable of producing far-reaching decomposition of albuminoid matter tend to increase.

Working on the assumption that senility is partially due to the absorption of by-products

[1] Chap. I.

[2] Metchnikoff, *The Prolongation of Life*, 1908, p. 161.

formed from albuminoid food by the decomposing or putrefactive bacteria mentioned, Metchnikoff instituted a search for organisms capable of suppressing the growth of the putrefactive bacteria.

It has long been known that milk allowed to become sour will keep for a considerably longer period in hot weather than if lactic bacteria had not grown. This preservative action of lactic acid also comes into play in the manufacture of sauerkraut and in the preservation of meat by immersion in sour milk.

Bienstock has shown that the growth of *Bac. putrificus* is inhibited by the action of *Bact. coli commune*, which is capable of setting up a slight lactic acid fermentation. *Bact. coli commune*, however, gives rise to substances of an injurious character, and, although present very abundantly in the intestinal tract, it may by reduced almost entirely by the active growth of lactic acid bacteria. This fact is of great value to the cheesemaker, since by the addition of a lactic acid culture (starter) to milk before renneting, gas-producing bacteria such as *Bact. coli* may be checked in growth. Since the ordinary lactic acid bacteria such as *Streptococcus lacticus*, *Bac. lactis acidi*,

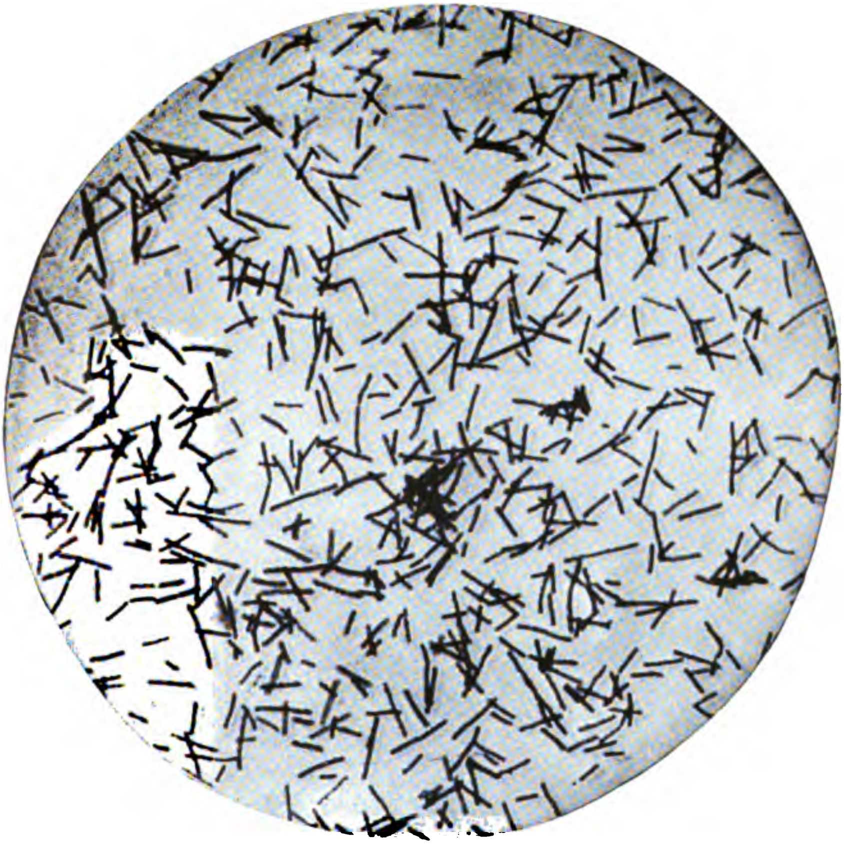


FIG. 34.—Photo-micrograph of smear of culture of ***Bacillus bulgaricus***, recommended by Metchnikoff for use in cases of intestinal auto-intoxication. Unlike the ferments of normally soured milk, which are sometimes indifferent, or even injurious, in their action, this bacillus is capable of growth at blood heat, and, by producing much larger quantities of lactic acid than such organisms as ***Streptococcus lacticus***, ***Bacillus coli commune***, or ***Bacteria lacticus aërogenes***, inhibits the multiplication of bacteria responsible for the putrefaction of albuminoid food in the intestines.

and others, are incapable of growth at blood temperature, it appeared necessary to procure cultures of lactic bacteria able to grow at temperatures of 100° F. to 112° F. Such an organism was found in Bulgarian soured milk (yoghourt), and was considered pre-eminently adapted to this purpose. As has been shown in the preceding paragraphs, this organism is merely one of a large group of bacteria found distributed in the intestinal canal of many domestic animals, in manure, and in ordinary market milk. It is then not surprising that the introduction into the intestinal tract of bacteria of the type *Bulgaricus* in the form of tabloids has not met with any decided success. Although it was considered to be merely necessary to introduce the desired type of organism into the body, and the amount of lactic acid taken into the system by the administration of soured milks was looked upon as of secondary importance, yet, it would seem, in the light of recent investigations, that benefits derived from a soured milk regimen are attributable in part to a chemical as well as a purely bacterial action. This receives support from the fact that soured milk beverages prepared by the use of ordinary lactic bacteria, distinct from those of the *Bul-*

garicus type, often exert a beneficial influence upon human beings even although the organisms responsible for the fermentation are incapable of growth at blood temperature.

It may be mentioned in conclusion that cultures prepared by the use of organisms of the type *Streptococcus lacticus* combined with *Bac. bulgaricus* possess a more agreeable flavour and aroma than those prepared from a pure culture of *Bulgaricus* alone.

FIG. 35.—*Bacillus bulgaricus*, showing the cultures in English cow's milk. (Magnified 450 diams.)

FIG. 36.—Photo-micrograph of pure culture of *Bacillus bulgaricus*. The administration of cultures of this organism is indicated in all cases of intestinal ailments, caused by the excessive growth of proteolytic bacteria, and consequent putrefaction of foods in the alimentary tract. By the formation of large quantities of lactic acid, a state of asepsis is ensured, which is particularly valuable in cases of operations on the abdomen and intestines.

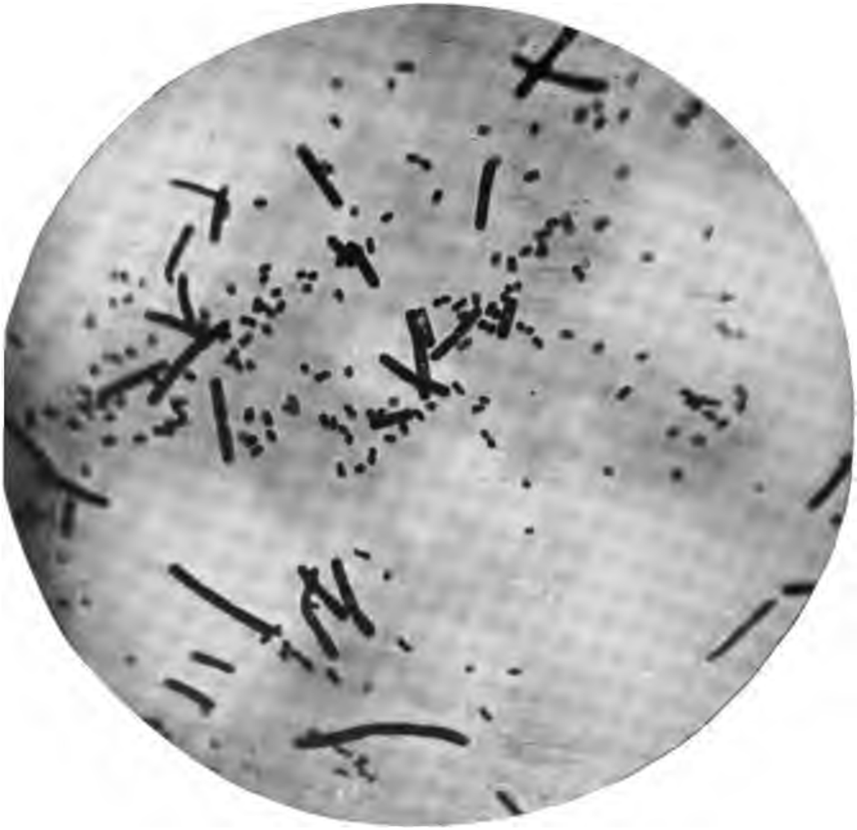


FIG. 37.—Photo-micrograph of smear of combined culture of *Bacillus bulgaricus* and *Bacteria paralacticus.* This double culture possesses an advantage over single cultures in that, while the characteristic disinfecting action of the former is retained, any secondary action of the growth of this organism upon the milk-fat is checked by the growth of *Bacillus paralacticus,* thus ensuring the production of a more palatable product.

CHAPTER VI

THE PREPARATION OF SOURED MILK IN THE HOUSE

THERE is no great difficulty in making soured milk at home: the necessary operations are quite simple, but at the same time they must be conducted with precision and care, otherwise the results may be unsatisfactory and disagreeable; there may even sometimes be danger in badly prepared sour milk. It is always an advantage in such matters to understand the reason of things, and a few notes on the surrounding conditions, and what has to be accomplished, may be of assistance to the would-be experimenter.

The majority of intelligent people are now acquainted with the fact that the germs of bacteria are to be found everywhere on the surface of the earth, in air, and in water, and that they are the sole cause of the decay of all manner of perishable articles.

The distribution is unequal—bacteria are much

more plentiful where there is decaying matter—in dirty houses, sewage, or other contaminated water, etc. Milk is a splendid food for bacteria, and numerous varieties multiply in it exceedingly, and many of these are injurious, producing putrefactive changes which render the milk unwholesome, even poisonous in some cases. Others are beneficial, and are absolutely necessary for the souring of milk for making butter or cheese and for the ripening of the latter. The soured milk which is the subject of this book is the work of certain lactic-acid-producing bacteria, and the problem we have before us is to encourage the growth of the latter to the uttermost and to exclude the others.

As bacterial germs are present in the air and readily sow themselves into any medium with which they come in contact, the first consideration is to get good fresh milk which has been as little exposed to the air as possible. The second is to conduct the experiment where the germs are fewest, and in cleanly surroundings, far removed from decaying matter and free from taints and smells.

However fresh the milk may be, it will contain useless or injurious bacteria, and we must

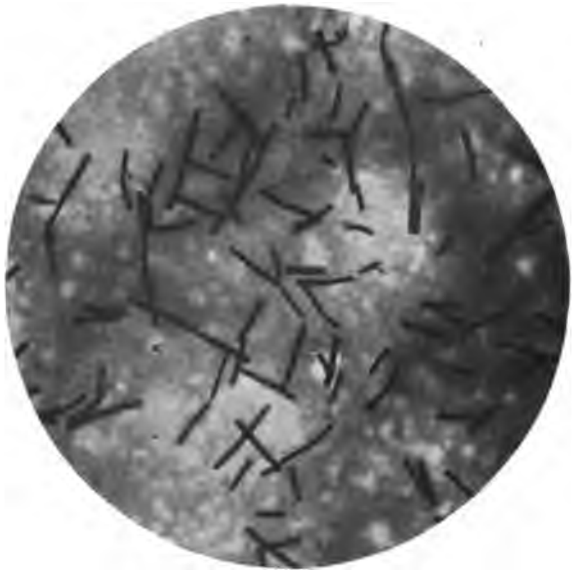


FIG. 38.—Photo-micrograph of smear of one-month culture of *Bacillus bulgaricus*. In spite of its age, the culture is perfectly free from any foreign organisms, which would otherwise lower its value for the preparation of soured milk, and might, indeed, make it directly injurious.

FIG. 39.—Photo-micrograph of culture of *Bacillus bulgaricus* in malt. In cases of acute enteritis, where milk cannot be supported, the lactic bacilli may be cultivated in malt, and administered to the patient in this form, with occasional doses of syrup of malt, in order to induce a vigorous growth of the lactic ferments in the body.

FIG. 40.—Photo-micrograph of smear from milk that had been allowed to sour spontaneously. Ordinary market milk is always subject to infection from the air, milking vessels, manure, etc., and from these sources a mixed bacterial flora arises, with the result that the milk exhibits curdling, acidity, gaseous fermentation, or mould growth, after being stored for a short time. This is due to the action of such bacilli, diplococci, yeasts, and moulds as are shown in this illustration.

get rid of these before attempting to introduce those whose growth we wish to encourage. This is effected by heat. All the living bacteria and most of the germs are killed at temperatures somewhat under the boiling point. Having sterilised the milk in this way, it is necessary, as far as possible, to prevent the entrance of fresh germs from the atmosphere, and we therefore let the milk cool down in covered dishes. When the temperature descends to about 100° F. the culture of the special bacteria is introduced, the covers are replaced, and the milk vessels maintained at or near this temperature for twelve hours, when the soured milk is ready for use. It is not necessary to use fresh culture every time—a little of the soured milk will take its place, and this may be repeated as many as fourteen times before it is necessary to start off again with a fresh culture. A great deal depends on the care exercised and the freedom of the surroundings from bacterial germs. Under the best conditions wild germs will gradually accumulate in the soured milk, but their increase may be greatly delayed by attention to the precautions mentioned. The ordinary souring of milk for butter and cheese making is conducted in cool surroundings, as

already stated, because in such conditions the lactic-acid-producing germs increase relatively faster than the wild germs, and so gain the upper hand, but in the case of our special soured milk we kill out, practically, all wild bacteria and germs, and the pure culture having the field to itself, we can conduct the operation at a higher temperature where the action of the bacteria is at its maximum, and so obtain the necessary lactification in the minimum of time.

The appliances for the souring of milk on the domestic scale require some consideration. We propose to describe the principal forms of apparatus which have been put on the market for the purpose, and then to give such suggestions as may assist the ingenious in making apparatus for themselves. Those who wish for information on the subject of larger apparatus will find it in the following chapter.

The Society "Le Ferment" of Paris, which has been authorised by Professor Metchnikoff to prepare and supply to the public his sour milk culture, provides an apparatus for the treatment of the milk. It is shown in Fig. 45, which consists of a double box having the intervening space packed with a non-conducting material. It is

FIG. 41.—Photograph of Agar Culture, inoculated with a lactic powder offered to consumers under a fancy name. Working on the assumption that the presence of lactic bacteria is inimical to the growth of septic organisms, this preparation has been placed on the market.

The plate shows, however, an abundance of colonies of foreign organisms—sporogenous bacilli, *Staphylococcus pyogenes albus*, and *Staphylococcus pyogenes aureus*. These organisms are shown in the appended photo-micrographs, and constitute impurities in the preparation.

Spore-forming bacillus.

Staphylococcus pyogenes albus.

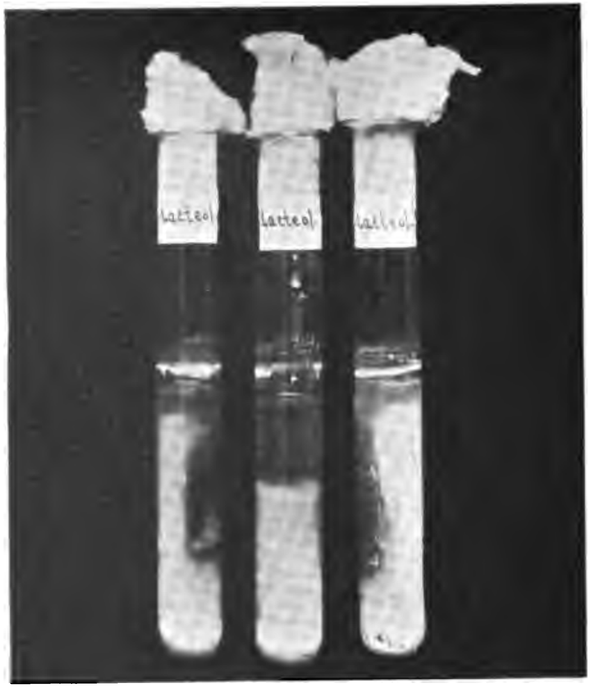


FIG. 42.—Photograph of Test Tubes of Sterile Milk, inoculated with a tablet preparation said to contain pure cultures. The darker liquefied portion of the tube-contents is due to digestion of the curd by proteolytic bacteria, thus indicating impure culture. Pure cultures of lactic acid bacteria coagulate the milk uniformly, but do not produce any subsequent change in the appearance of the culture, even after several months.

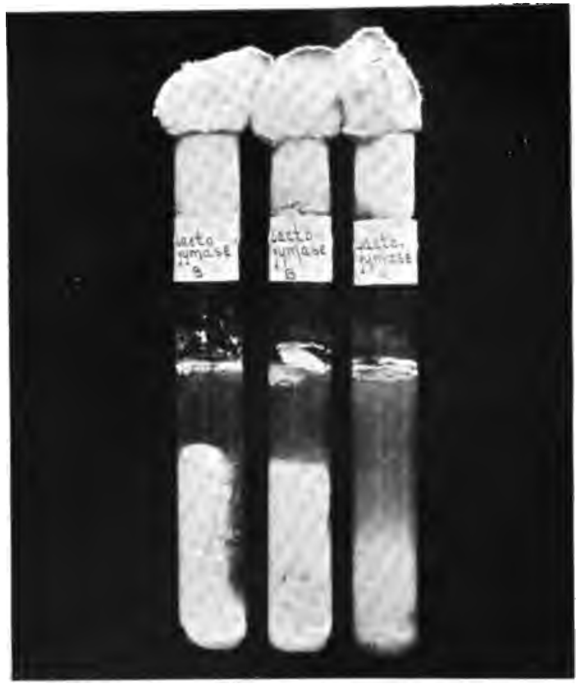


FIG. 43.—Photograph of Test Tubes of Sterile Milk, each tube having been inoculated with a tablet of a preparation said to contain pure cultures. Here, again, there is evident peptonisation of the curd, thus indicating infection by proteolytic ferments. Cultures from these tubes demonstrated the presence of a foreign organism. Microscopical examination failed to disclose the presence of *Bacillus bulgaricus*.

provided with a tight lid. Inside, there is accommodation for two milk vessels, each with a capacity of about two thirds of a pint. The most difficult thing in the souring of milk is to main-

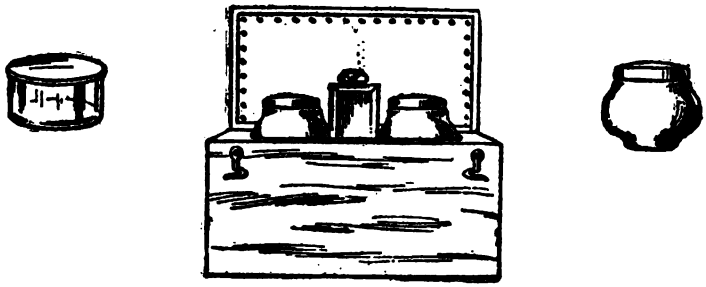


FIG. 15

tain the temperature as nearly at 100° F. as possible while the culture is in action. This result is attained by filling the vessel in the middle with boiling water. The insulated walls hinder the escape of heat, and the quantity of boiling water used is calculated to maintain the temperature steady for the twelve hours of cultivation; but in cold, frosty weather it is necessary to refill the central vessel with boiling water in the middle of the period.

The milk jars are washed with hot boiled water and turned upside down to dry. They should not be wiped with a cloth. Boil the milk to be

treated for ten minutes, stirring it to promote evaporation, as it is advantageous to have it in concentrated form. Cool rapidly to 100° F. by placing the boiling vessel in cold water, add to each bowl one third of a tube of the culture in powder form, fill up with the boiled and cooled milk, stir well and cover. Place the jars in the box and fill the central vessel with boiling water, shut the lid tight, and do not open it (unless a fresh charge of boiling water is needed) for ten or twelve hours, when it will be ready for use. If the liquid culture is used (one small phial for each bowl) the milk should be cooled to 86° F. instead of 100° F., as with the powder. The culture is also supplied in tabloid form. The powder and tabloids keep well, but the liquid can only be relied on for about two months. The milk prepared as above should be stored in a cool place, the lids being kept on the bowls. It is good for about two days, after which it becomes too sour. It can be eaten with sugar, which not only sweetens it but is beneficial in affording additional suitable food for the acid-producing bacilli. If fresh milk cannot be had, condensed, sterilised, or pasteurised milk may be used, but, of course, fresh milk is best. Condensed milk

FIG. 44.—Photograph of Test Tubes of Sterile Milk, inoculated with a tablet of "Lactobacilline." In contradistinction to those shown in Figs. 42 and 43, these tubes exhibit homogeneous curdling of the milk without any subsequent digestion or peptonisation of the coagulum. This is indicative of the purity of the culture.

FIG. 46.—Soured Milk Apparatus of the Maya Bulgare Company, Limited, consisting of an insulated box, hot-water vessel, and covered vessels containing the milk and culture. The apparatus consists of cabinet in deal, Maya Bulgare ferment in 20-dose bottles, Maya Bulgare ferment in 100-dose bottles, compressed Maya Bulgare tablets in boxes of 8 tubes, Maya Bulgare caramels in boxes of 40, reduced milk, china funnels, and thermometers.

should be diluted with two parts of boiling water and then treated like ordinary milk.

An apparatus on similar principles is sold by the Maya Bulgare Company, Ltd., and is illustrated in Fig. 46.

The box is insulated, but the door is on the side, the hot water vessel is underneath, and the covered vessels containing the milk and culture are placed on a shelf above. In the front of the illustration are shown the various packages in which the liquid and powder cultures are put up. The procedure is exactly the same as with "Le Ferment" apparatus.

Lactic Ferments, Limited, make use of a different principle to maintain the temperature steady during the lactifying period. Their apparatus (Fig. 47) consists of a water vessel mounted on a stand. The milk vessels (tumblers) are placed in the water, and the temperature maintained at the proper figure by a small night light burning underneath. It is recommended that the milk should be placed in an earthenware jar or jug, which is stood in a pot of water kept

FIG. 47

boiling for an hour. After cooling add from three to six previously crushed tabloids of culture, and stir well with a glass rod which has been sterilised in boiling water. The milk is then transferred to three tumblers, which it should fill, and these are put into the water vessel, the water in which should be at about 100° F., and the night light started.

Messrs. Allen & Hanbury, Limited, also make use of the night light to maintain the proper temperature during incubation in their "Sauerin" apparatus (Fig. 48).

No water, however, is placed in the metal container. The procedure is the same as that already described, and both tablet and liquid pure cultures are supplied. For children it is recommended that the incubation should occupy from three to four hours only, in other cases eight to ten hours. Grated nutmeg, ground cinnamon, or other flavouring, and cream may be used with the soured milk.

The night light is also employed in the "Veronelle" apparatus of Messrs. Clay, Paget and Company, Limited (Fig. 49).

The containing vessel is of tin or aluminium, and has two stands, the high one for hot and

FIG. 48.—Messrs. Allen & Hanbury's Soured Milk Apparatus. They maintain the temperature by means of a night light, and the culture they use they call "Sauerin."

FIG. 49.—Vironelle Apparatus for souring milk, made by Messrs. Clay, Paget & Company, Limited. The milk in this case is placed in an earthenware jar, and is sterilised by placing in a saucepan of water and boiling it. The culture is added after cooling, the period of incubation being about six hours.

the low one for cold weather, as in the latter case greater heat is needed to maintain the incubating temperature. The milk is placed in an earthenware jar and is sterilised by placing it in a saucepan of water and boiling it; continuing the boiling for half an hour. It is allowed to cool to about 98° F., and placed in the incubator, culture added, and the lamp lighted, the cover of the incubator being kept on. The period of incubation is given as six hours. To prepare the next day's supply a tablespoonful of the soured milk is retained and used instead of the culture. This may be continued for fourteen days, when a fresh start with culture is necessary. The soured milk will keep for thirty-six hours. Capacity, one and one half and two pints; also a large size for family use.

For the preparation of soured milk on a small scale, one of the various forms of vacuum flasks now on the market may be used with satisfactory results. A little cold water must be poured into the flasks, and warm water added, until, by means of three to four changes, boiling water can be safely poured in without cracking the flask.

This boiling water must be allowed to remain in for about twenty minutes, and then replaced

by freshly boiled milk that has been cooled, so that its temperature in the flask is about 105° F. The culture of lactic organisms should then be added, the opening of the flask plugged with clean cotton-wool, and the cap screwed on.

In an actual test, the temperature of the milk placed in such a flask was 105° F., at 7.30 P.M., and had dropped to 93° F. by 9 A.M., the following day. The milk was curdled, and possessed the normal acid taste of such cultures.

The different types of apparatus are all quite simple, and it would be easy to make something at home. Get two round tins, the one less in diameter by from two to three inches than the other, put one or two pieces of wood across the bottom inside the larger tin, and fill up the space between with cotton-wool, which is an excellent non-conductor of heat. Place the smaller tin centrally inside the larger one. Fix three or four distance pieces of wood in the space between them, fill up with cotton-wool, leaving a little space at the top to permit the lid of the smaller tin to be fixed on. The boiling-water vessel may be a tin saucepan with a lid, but no handle, and its proper place would be on the bottom of the inner tin. A tripod stand made of three pieces of wire bound

together, and with legs reaching past the hot-water vessel to the bottom of the tin, would support a false bottom of tin forming the shelf on which the vessels of milk to be treated would rest. These might be tumblers covered with tin lids. To prevent radiation through the lid of the inner tin, a thick pad or hood of cotton-wool packed between cloth would be placed over the top. A little experimenting would be necessary to determine the quantity of boiling water required to maintain the proper temperature.

The soured milk obtained in the above manner is of the consistency of ordinary buttermilk; a separation of whey frequently takes place, and this may be poured off if desired. The taste and flavour should be pleasantly acid and agreeable, and both are distinctive enough to give a good idea of the purity of the product. In many places a more concentrated article is made by boiling down the milk to one half or one third of its bulk, and then fermenting it in the ordinary way. A kind of thick pudding is thus obtained, which is highly recommended both as an agreeable article of food and as a stronger medium for the support of the germs it is the purpose of the

sour milk treatment to introduce into the digestive system.

The cultures for making soured milk can now be had from all the leading wholesale and retail chemists, with directions as to the quantities to be used.

It is very necessary that the milk used should be not only fresh and good, but also free from chemical preservatives. The effect of these is to inhibit the growth and development of bacteria, and they have therefore an injurious influence on the special lactifying germs it is our object to cultivate. Preservatives are now not nearly so much used as they were a few years ago, and there should be no difficulty in obtaining milk free from them.

For keeping both fresh and soured milk good a small ice-chest is an excellent device. The germs which are continually dropping into milk kept in open vessels in the air, even in cleanly surroundings, are mostly kept out in the close ice-chest, and the low temperature prevents in a natural way the development of the bacterial germs already in the milk. For the preservation of all kinds of foods the ice-chest is a capital investment, not to mention the benefit of having

cooled drinks, etc., as required. They manage things well in this respect in the United States, where ice is regarded as a necessity in the summer time by even the poorest people, and is delivered with the same regularity as the milk.

It is necessary to utter a word of warning as to certain forms in which the sour milk bacillus is being offered to the public. It is being compounded with sugar, chocolate, and other articles, and sold in the form of sweets, etc. There is no reliable proof that these preparations are valuable. Certainly, sugar is a medium in which the lactifying germs can live, but the quantity so introduced into the system must be very small compared with what is obtained from properly fermented milk. It takes some time, even with strong cultures, to fix the acid-producing germs in the large bowel where they are wanted, and until proper evidence is forthcoming that confectionery preparations are efficacious we would recommend that only the regularly fermented milk be used. It would save trouble, no doubt, to treat oneself with a few chocolate creams containing the necessary germs daily, but if the matter is taken up seriously it will be better to take some pains and stick to methods the efficacy of

which has been demonstrated, leaving the others until their *bona fides* has been proved. There are always enterprising firms who are prepared to simplify things for us, but we must make sure that their simplifications are warranted.

CHAPTER VII

THE PREPARATION OF SOURED MILK IN THE DAIRY

THERE is a tendency in certain meaical quarters to discourage the use of soured milk "made for profit." This view leaves out of account the fact that besides being of value in medicine, the article in question is also an excellent food, which, as we have seen, has been consumed by multitudes of people for ages in many parts of the world. There seems also to be satisfactory evidence that a larger percentage than usual of the people who make soured milk a staple of diet attain to a ripe old age. How does it become such a dangerous thing the moment the doctors get it into their hands? Of course if a man has an acute disease he places himself entirely in the hands of his medical man, and eats what is prescribed for him, or at least he ought to do so, and if he makes such a submission he is entitled at least to the comfort of being able to feel that his doctor is free

from unreasonable prejudices. For the implication that an article "made for profit" is naturally suspect casts an unwarranted stigma on a large number of honourable people. There are dishonest tradesmen just as there are dishonest and careless doctors, but to saddle a whole class with the offences of a few would not be a justifiable proceeding in either case. Besides, it is not to the interest of the manufacturing chemist or the dairyman to turn out spurious cultures or bad soured milk, and on the whole we see no reason why they should not engage in the business.

The widespread use of soured milk in other countries as a regular article of diet seems to indicate that all manner of people, except those suffering from diseases which necessitate medical regulation of diet, might with probable benefit to themselves add this article to their food list; and it looks as if a good many of them intend doing so, even if scandalised doctors threaten "to abandon the cure."

The dairyman who knows his business does not need to be told of the care which is necessary to keep milk in good condition. The merely commercial consideration of avoiding loss has made him ready to inquire into the best means of pro-

FIG. 50.—" Lactobator " made by Messrs. Charles Hearson & Co., Limited, which is used for the incubation of pure culture in milk in a fairly large way. The illustration shows the " Lactobator " closed.

longing the life of milk as a merchantable article. For a time he relied on chemical preservatives, but their day is now almost over, and filtration, pasteurisation, and cold storage have taken their place. Any one conversant with the trade knows how widely these methods have been adopted of late years; we may, therefore, assume that the average dairyman has at his command milk suitable for the incubation process.

The demand for soured milk is not as yet a very large one, and the apparatus so far developed for its production is meant for the treatment of small quantities. After describing the principal appliances at present in the market we propose to make some suggestions as to the construction of larger apparatus.

A firm which has given great attention to the question of maintaining fixed temperatures is that of Messrs. Charles Hearson & Co., Ltd. Their incubators for chicken hatching are known all over the world; and their appliances for biological incubation are very generally used in bacteriological laboratories. With such experience it was natural that they should turn their attention to soured milk apparatus, and the result is the "Lactobator" (Figs. 50 and 51).

A copper vessel made to contain water has placed in it a stoneware jar which holds two gallons of milk; on the top is a lid which carries a thermometer for indicating the temperature of the milk. Heat is supplied by a gas ring under the copper vessel; and in the gas supply is the patent thermostat made use of by Messrs. Hearson also in their biological and poultry incubators, in which a capsule containing a liquid arranged to boil at a certain predetermined temperature is the regulating factor. When the liquid boils, the capsule expands, and by certain mechanical devices regulates the gas supply so as to produce exactly the temperature required.

The procedure is as follows: The jar is filled with milk, and water is run into the copper vessel by the funnel until it runs over at the overflow pipe. The thermostat is lifted off and the full gas supply allowed to pass to the burner, the temperature of the milk brought up to 180° F. and maintained for half an hour at this figure. The gas is then turned off, and cold water run through the funnel until the temperature of the milk registers 95° F. The culture is added, the lid replaced, and the thermostat put into the pocket at the side of the vessel; the gas relighted, and

FIG. 51.—Messrs. Hearson & Company's "Lactobator," showing the internal arrangements.

when the temperature reaches 100° to 106° F. the capsule of the thermostat will expand and close the gas to a peep, which is just sufficient to maintain the temperature within the above limits. After eight hours the incubation is completed.

Edgar's patent apparatus, the "Lactogenerator," as provided by the Dairy Supply Co., Ltd., is shown in Fig. 52.

The milk is placed in a tinned copper-jacketed vessel and water run in through a vertical pipe until it runs off at the overflow. Two gas connections are required with cocks on each, the one to heat up the milk to the boiling point and maintain it at this for thirty minutes. A skimmer which has been placed in the milk lifts out the coagulated protein and albumen which rise to the top. The cock is then shut and cold water run through the jacket till the thermometer shows 90° F., when the culture is added, and the other gas supply with the regulator turned on, and the temperature is automatically maintained at about 90° F. Time of incubation eight to nine hours. It is recommended to turn cold water

FIG. 52. Edgar's "Lactogenerator"

into the jacket at the end of the period to prevent overincubation.

A somewhat similar apparatus is that of the Willows Refrigerating Co., Ltd. (Fig. 53), with

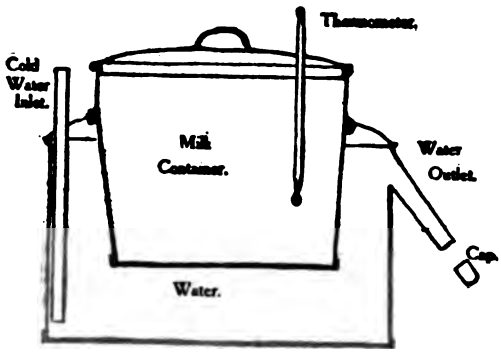


FIG. 53
Apparatus of the Willows Refrigerating Co., Ltd.

the exception that it has no automatic heat regulator. It is made of tinned steel, and the operations are the same, but the sterilising temperature (obtained by a gas ring or hot plate) is given as 180°, and the incubating temperature 100° to 104° F. for a period of twelve hours. Presumably this temperature is maintained by a small gas jet or other similar source of heat. The capacity is two gallons.

In the apparatus hitherto described the milk is sterilised in bulk, and is filled into bottles or

jars after incubation, which is not a desirable thing to do, unless the soured milk is for immediate consumption, as there is likely to be contamination with injurious germs from the atmosphere. In the domestic apparatus the milk is usually incubated in covered jars in which it can be kept until required for use, and the practice or the larger scale should be the same.

The Dairy Outfit Co., Ltd., have recognised this in their "Lacto" apparatus (Fig. 54).

Fig. 54
"Lacto" Apparatus of the Dairy Outfit Co., Ltd.

A cylindrical vessel is set loosely on a stand, beneath which is a lamp calculated to maintain the incubating temperature. The milk is placed in bottles with metal screw tops, and these are put into the cylindrical vessel; water is run in round them through the side funnel, the vessel lifted off the stand, and heated to sterilising point on a stove. Cold water is then run in through the funnel until the temperature is low enough for

incubation. Culture is added to each bottle and the lids screwed on, the vessel lifted on to its stand, and the lamp lighted. The cover of the apparatus has a thermometer fixed on it.

On the large scale the treatment of the milk would take place entirely in the jars in which it would be sent out, and the sterilisation and incubation would be conducted in different pieces of apparatus. The sterilisation would be effected either (1) by direct steaming, or (2) by hot water heated by steam. Fig. 55 shows the first type of sterilisation. The tank is of wrought iron or steel with strengthening pieces of angle iron. The door, with pulleys and counterweight for easy handling, is fastened steam-tight by hinged bolts. The apparatus is mounted on a stand at a convenient height for handling the bottles; and in front is another stand with channel iron rails to take the waggon in which the bottles or jars to be sterlised are packed. When the door is fast, steam is turned on, and regulated to produce the proper temperature by the thermometer fixed in the shell, in which a pressure gauge is also secured. After sterilising, the door is opened and the waggon drawn forward to the outside,

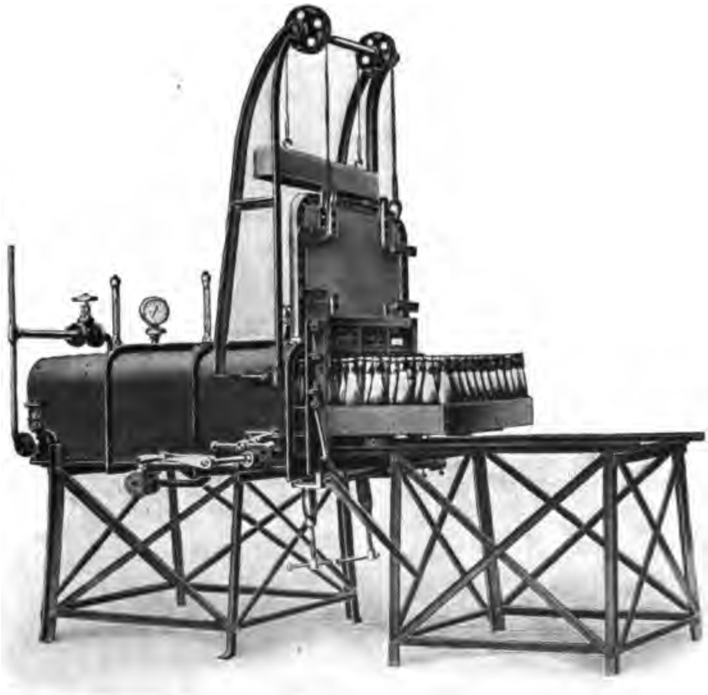


FIG. 55.—Sterilising Apparatus for sterilising milk on the large scale. The bottles of milk are sterilised, and the culture can then be added, and the incubation allowed to proceed in an insulated chamber.

allowed to cool, or removed elsewhere to cool, and allow space for a new charge.

The second method of sterilising is by hot water, as in Fig. 56. The bottles or jars are placed on a perforated false bottom in the rectangular tank, water run in up to the necks, and steam turned on; the lid is fastened with hinged and hooked bolts; a thermometer fastened in the lid, and with a long stem enclosed in metal, indicates the temperature. At the end of the sterilising process cold water is turned on, and at the same time the overflow water cock is opened; the cold water gradually reduces the temperature, and the incubating point is quickly reached.

Incubation in bottles or jars, sterilised in these ways, can best be conducted in an insulated room, with say, six inches of silicate cotton, granulated cork, or washed cow hair packed between two-inch by six-inch battens, covered with matching on either side, and lined with sheet zinc. It would be an advantage to have an air-lock or anteroom into which the waggons or trays of sterilised jars could be run, and the door of the anteroom closed before the door of the insulated room is opened. This would tend to prevent variations of temperature in the room, and also,

by checking free communication with the outside air, decrease contamination. The waggons of jars would be run in, and culture added to each jar by a sterilised pipette. The atmo-

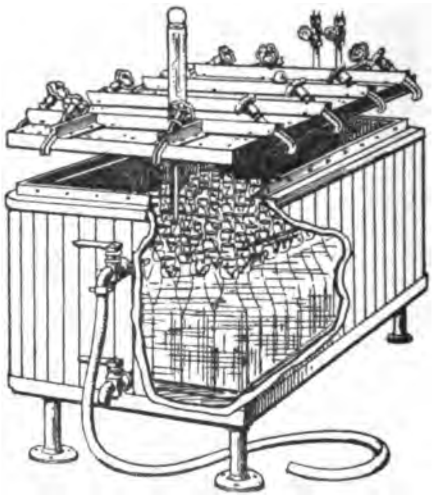


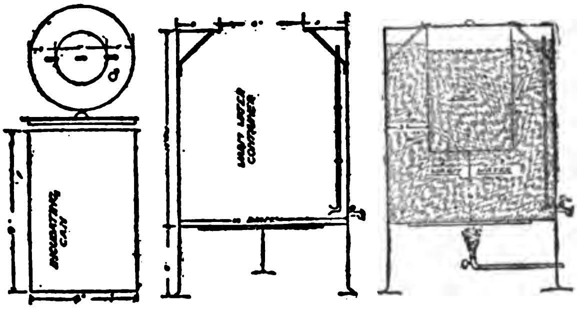
FIG. 56
Another Method of Sterilising (Dairy Supply Co., Ltd.).

sphere of the room would be kept pure by running in air frequently through a filter of moist cotton-wool by means of an electric fan, and at intervals the interior would be sterilised by the use of formalin vapour.

The incubating temperature could very conveniently be maintained by an electric radiator,

Details of an American Apparatus for Preparing Soured Milk

A B C



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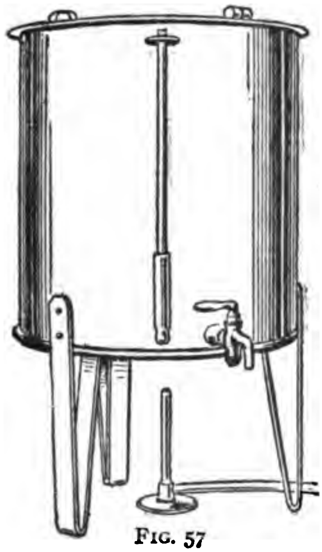

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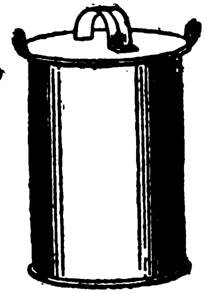

FIG. 57

The figures give diagrams A, B, C, and D of an apparatus useful for the preparation of lactic foods. The incubating can A, is made of block tin, and is intended to contain the milk. B, the warm water container, should be a stout walled vessel with a circular aperture in the lid, through which the incubating can may be passed, and clamped down as in C.

B is fitted with three stout iron legs, which should be sufficiently long to allow of a small lamp or gas-jet being placed beneath the container to maintain a uniform temperature.

D gives an external view of the apparatus.

For the preparation of soured milk, separated milk is placed in the incubating can, and heated up to 100° C. (212° F.) for thirty minutes. It is then allowed to cool to room temperature, and the culture, or tablet containing the lactic acid bacteria, is then added, and thoroughly stirred for a minute or so. The can is then immersed in the warm water container and kept at a temperature of 86° F. to 104° F., according to the organisms used, for ten to twelve hours. By the end of this time the milk ought to be converted to a jelly-like mass, and after being stirred vigorously for a short time, may be cooled on ice, and is then ready for consumption.

and as the insulation would largely prevent leakage, the amount of electric current used would not be large. The regulating apparatus might consist of a thermometer with platinum wires fused through the stem at the proper temperature, say 100° F. When the mercury rises to this figure it will complete the circuit of a battery which will actuate certain well-known devices for turning off the current which actuates the radiator. In this way a very fine automatic arrangement would be achieved. Steam pipes might be used instead of the radiator, and the thermometer above described could be used in this case also, with appliances to cut off the steam.

On the large scale, labour-saving appliances, such as the mechanical brush jar and bottle washer, and the automatic filler for jars or bottles, would be employed, and an overhead trackway for carrying the trays of jars from the steriliser to the incubator would be a great convenience. A further adjunct of considerable importance would be a cold room, worked either by ice or a refrigerating machine, in which the jars could be stored after incubation, so as to arrest the process of lactification, and maintain the soured milk in good condition until required for use.

CHAPTER VIII

SOURED MILK IN HEALTH AND DISEASE

When people are ill the best thing they can do is to place themselves in the hands of the doctor, who will try to regulate their lives, including their diet, in accordance with the conditions which science suggests as the most likely to lead to their recove y.

It is not the aim of this book to teach persons who should be under medical treatment to doctor themselves; soured milk may or may not be beneficial in their case—that is for the medical man to say; and further, if it should be beneficial the doctor ought to have its preparation under his control. Slight differences in quality and purity may count for much in cases of acute disease, differences which might not matter to the person who requires no medical attention, and who consumes the article as a health-giving food. A considerable body of evidence is already

on record as to the potency in certain cases of soured milk as a curative agent, and it seems to have taken its place in medicine as a recognised remedy.

There is a wide field of usefulness, however, outside of the strictly medical one. Professor Metchnikoff has collected many striking examples of individuals and peoples inhabiting different parts of the world, who thrive, and in many cases attain to a great age, and whose diet consists largely of soured milk. He has made a wide and general inquiry into the causes which tend to shorten life, and makes out a strong case in support of the view that in many cases this is the result of what is called auto-intoxication or self-poisoning. In man and in the mammalia generally, the colon or large intestine is very largely developed; this organ is not of much value in the digestion of food, and seems to be chiefly a receptacle for waste material; it is, as a rule, extremely rich in bacterial flora, which produce putrefactive changes in the waste material. As a result various poisonous principles are evolved, and these find their way into the blood, accompanied frequently, there is every reason to believe, by the injurious bacteria themselves. In this way many

diseases and ailments are produced which shorten life. The inquiry then naturally turns to what is the best way of dealing with this state of matters. It is known that the bacteria referred to flourish best in alkaline or at least non-acid surroundings, and it is known that these conditions very frequently exist in the large intestine. Acids are the best antiseptics; they have been used from time immemorial as preservatives; pickles are preserved in vinegar or acetic acid, and when milk is allowed to sour under proper conditions, the germs of putrefaction are destroyed or their activity inhibited, and it keeps a considerable time. Doubtless, in hot countries, it was this property of lactic acid which first led to milk being artificially soured with a view to its preservation as an article of food. So powerful is lactic acid in this respect that it is a custom in some countries to preserve meat by placing it in soured milk.

How can acids be applied so as to control the bacterial flora of the large intestine? Not in the ordinary way, because, when administered through the mouth, they are used up long before they can penetrate to the colon. The brilliant idea occurred to Professor Metchnikoff, of administering acid-producing germs which might work their way

through the digestive system, and, reaching the large intestine, produce the acid required. After much experimenting the bacillus of Massol, *Bacillus bulgaricus*, was adopted as the most suitable. The Bulgarian bacillus is an extremely vigorous one, multiplying with great rapidity, and persisting in conditions that would be inimical to other microbes. The growth and development of bacteria is interfered with by the products of their own activity; thus, ordinary lactic-acid-producing organisms die when a certain amount of lactic acid has been developed; the same fate overtakes the Bulgarian bacillus, but it survives longer and is able to produce as much as two and one half per cent. of lactic acid in milk before it ceases operations. It seemed therefore the most likely to be able to survive the journey through the digestive system. Experiments fully bore out this supposition, as no great difficulty was encountered in naturalising the Bulgarian bacillus in the large intestine, not only in milk cultures, but grown in solution of malt, bouillon, etc. It thrives in all kinds of sugar, and therefore can be administered in a variety of media, very beneficial results following in many cases. Direct tests showed a large reduction of the injurious intestinal

flora when the Bulgarian bacillus had been naturalised in the colon, and the bacillus persisted long after it had ceased to be administered. Specialists who have taken up the subject report the cure of many ailments through the agency of soured milk, and it seems to have entered upon a lengthening career of medical usefulness.

The fact of so many old people being found in countries where soured milk is a staple of diet naturally raises the question as to whether its general use in other countries might not have a beneficial effect on health and longevity. Its usefulness as a remedial agent in certain diseases is already demonstrated; is there not a strong probability, amounting almost to a certainty, that its consumption by people in health would tend to ward off many ailments and prolong life? Of course there will be some for whom it is not suitable; there are people who cannot eat strawberries without discomfort, but no one thinks of prohibiting the general use of the fruit on that account. In the matter of diet the person in health, if he exercises ordinary care, may be left to find out for himself what suits him. The soured milk remedy is not a disagreeable one, as, when properly prepared, the article forms

both a pleasant and refreshing article of diet. The question of getting the right article, however, is a very important one. Milk is a splendid rearing ground for many bacteria, some of which are very injurious; among these may be pathological germs, the seeds of tuberculosis, enteritis, etc. The danger with soured milk is, that in the process of culture we develop the best condition for the increase of these when they preponderate, or when, through the use of bad cultures, the lactic-acid-producing bacteria are absent, or present only in small numbers. By the thorough boiling of the milk, we get rid of all living bacteria and nearly all spores or germs, and by scrupulous cleanliness in the vessels used—scalding or even boiling them, and allowing them to dry naturally in an inverted position—we greatly diminish the probability of infection with fresh injurious germs from the atmosphere. All depends on the purity of the culture employed; this can now be obtained, prepared in the most careful manner, from wholesale chemists making a speciality of its manufacture.

As we have seen, even the Bulgarian bacillus is ultimately killed by the products of its own activity, and the natural corollary is, that the life

of cultures cannot be a long one. Only those cultures should be bought which are labelled with the date to which they are guaranteed to maintain their efficiency. With fresh good milk, careful boiling, scalding, and cleanliness with regard to the containing vessels, and the means of maintaining the incubating temperature for ten or twelve hours, there is not the slightest difficulty in preparing perfectly reliable soured milk. There are simple tests which will sufficiently guide the experimenter; the soured milk should not be too acid to the taste, and it has a flavour of its own by which its quality can be recognised. The litmus test-papers mentioned in the chapter on the chemistry of milk are very useful; both the red and the blue papers should be obtained and used first of all in testing the quality of the fresh milk. After incubation the soured milk should turn the blue paper decidedly red; if this does not occur, test it with the red paper; if the latter turns blue it is proof that the wrong fermentation has taken place—that putrefactive germs have gained the upper hand. The most probable explanation is, that the culture is bad, the Bulgarian bacillus is not present, or if so, only in small numbers. With these simple

tests, combined with proper care, one cannot go far wrong. The Eastern nations who prepare soured milk in various forms do not exercise the care we have predicated, but they seem to make the article of fairly constant and good quality. It has been suggested in explanation that, as the ordinary flora differs in different countries, the bacterial flora varies in a similar manner, and that in these Eastern countries injurious bacteria are not so prevalent in the atmosphere as they are with us.

It is also said that the flavour of the soured milk prepared in Bulgaria is quite different from that prepared in Paris, London, or New York; one reason probably is that the "maya" or ferment used in Bulgaria contains several other organisms besides the Bulgarian bacillus, which raises the question whether a pure culture of one bacillus is the best to use.

Professor Metchnikoff found that this bacillus alone had certain defects; it attacks fat and is apt to give a tallowy taste when cream is present in the milk. He therefore associated with it another lactic-acid-producing organism, and this combination is the basis of his culture called "lactobacilline." The presence of yeasts, which

occur in the Eastern ferments, has been advocated by some; the yeast in association with the lactic organisms produces a small amount of alcohol. The question of the composition of the culture will have to be fought out by the experts, but meantime, if we go to the right source, we have good enough cultures to go on with.

A good deal can be said for the use of skimmed or separated milk instead of whole milk. Cream as a rule contains far more bacteria than the rest of the milk, and we therefore start from a surer foundation when it is removed; besides, the mechanical separator, now so largely used, removes slime and other impurities from the milk, and these also are hotbeds of bacteria.

Soured milk may be taken at any time, the first thing in the morning, before or after meals, or the last thing at night. The quantity will vary with the individual, but from half a pint to a pint is a fair amount for daily use. If one wishes to have the maximum effect it is necessary for the time being to curtail the use of butcher's meat and substitute fish, yolk of eggs, and other similar foods; not much alcohol should be taken, and smoking might be reduced to a minimum. Those who cannot take even skimmed milk may

use whey in which to cultivate the bacillus; it is not desirable to employ the whey which has been separated by the use of rennet, as in cheese- or junket-making. A better article is obtained by adding a very small quantity of pure hydrochloric acid to milk which has been boiled, and then filtering through a sieve, which retains the curd while the liquid whey passes through; a pinch of soda is added to neutralise the excess of acid, and, after boiling, the liquid should turn red litmus paper blue; it is then ready for the addition of the culture and incubation in the same manner as with milk. A solution of malt—the extract dissolved in hot water is convenient—may also be used instead of milk, and strongly malted bread or biscuits are excellent to take with the soured milk or cultures in other mediums, to supply food for the bacillus in the form of malt sugar. Other sugars, cane or grape, are also very useful, and may be taken in the form of fruit juices, syrups, confections, jams, sweet puddings, etc.

We lay stress on the use of soured milk or other cultures of the Bulgarian bacillus by people in health as a probable preventive of disease and a possible agent in the lengthening of life, but it

may be of interest to give a short account of its use by medical men in the treatment of various ailments. An English authority on the subject, Dr. Herschell, states that the symptoms of the poisoning of the system by the toxic substances produced by injurious bacteria in the large intestine may include headaches, misery and depression of spirits, drowsiness and stupor, giddiness, dimness of sight and dizziness, fatigue without obvious cause, both of the muscles and brain, fear, panic, and nervousness, disagreeable sensations in the limbs or face, such as numbness, tingling, or prickling, crawling sensation of weight or of heat or cold, dyspepsia of the sort where there is a deficiency of hydrochloric acid and pepsin in the gastric juice, accompanied by flabbiness and loss of power in the muscles of the stomach, and characterised by flatulence, nausea, loss of appetite, with discomfort and weight after food, furred tongue, emaciation, earthy colour of the skin, offensive perspiration and the other signs of biliousness, enlargement of the liver, and anæmia. These symptoms may have other causes, and when one or several of them are present a chemical and physical examination of the urine and fæces is necessary to prove that they have

resulted from auto-intoxication. When this is shown the soured milk treatment is indicated, and many striking cures are detailed as witnesses to its efficacy. The liver and kidneys are the natural guardians of the body against the toxines we are speaking of, and frequently they are overstrained; the soured milk treatment greatly lightens their load. In malignant disease of the stomach, soured milk will frequently be retained when all other foods are rejected. In cases of neurasthenia and gout it has also proved of value, and in the "run-down" condition which is so common in middle life. Chronic diarrhœa and certain forms of constipation have in numerous instances yielded to the treatment, the whey culture being usually found the most suitable. Then, in some forms of anæmia, the lactic acid cultures have proved most successful, and, as a means of rendering the gastro-intestinal track aseptic previous to operations, they have proved of considerable value.

If all this has been accomplished in a year or two, what may not we look forward to in the future when more extended use and experiment shall have more fully exhausted the possibilities of the cure? But if we follow the example of the

different nations who have so long used soured milk as a regular article of diet, does it not seem probable that we may eliminate some, at least, of the causes of ill-health that call for the intervention of the doctor?

The human organism is by no means perfect; we have within us many defective parts, and some organs whose working seems to be against the welfare of the economy. It has now been clearly shown that one of the chief of these is the large intestine, as to the use of which only vague and unsatisfactory theories have been formed. There can be no doubt as to the damage which it frequently inflicts on the system, and, thanks to the researches of Professor Metchnikoff and other investigators, we seem to be in possession of a natural remedy which is sufficient to deal with the evils it produces.

INDEX

M

N

O

P

R

S

T

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